Environmental and Social Impact Assessment (Draft)

March 2018

THA: Chonburi Power Plant Project (Part 5 of 6)

Prepared by Gulf SRC Company Limited for the Asian Development Bank.

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5.1.2 HUMAN USE VALUES

5.1.2.1 Transportation

(1) Construction Period

The project development during the construction period included the transportation of equipment and machinery, and transportation of construction workers and materials. These activities may have an impact on the traffic volume in the local area. Therefore, the impact on transportation is evaluated by using the traffic data on the main routes such as highways and local roads around the Project site as well as the nearby communities. In addition, the increase in traffic volume as a result from the Project will also be used to calculate the ratio of increased traffic to the traffic capacity of the related highways and roads. The impacts are presented in V/C Ratio for the current traffic mobility in the local communities and during the Project development period. Details of impact evaluation methods are as follows:

• Classify vehicles into 8 types. Each type has multiply factors to change from passenger car unit (PCU) to passenger car equivalent (PCE), as shown in **Table 5.1.2.1-1**.

Vehicle Type	Passenger Car Equivalents (PCE) Factor
Passenger car and taxi	1.00
Mini- bus	1.25
Big bus	2.00
Small truck	1.50
Medium Truck	1.75
Big truck	2.00
Motorcycle	0.33
Bicycle, tricycle	0.20

TABLE 5.1.2.1-1 WEIGHING FACTORS FOR EACH VEHICLE TYPE

Source : Paopong, 1997 and Department of Highways, 2001.

• Designate V as traffic volume, to be calculated in the unit of maximum PCU/hr. Take V to calculate for V/C ratio, which is further compared with standard values of Traffic Engineering Division. The maximum allowed V/C ratio is 0.8 (80 %). The traffic carrying capacity of each highway type, as shown in **Table 5.1.2.1-2**.

TABLE 5.1.2.1-2

Road Type	Traffic Carrying Capacity (PCU/hr.)
Multiple lane highway	2,000 (per 1 lane)
Road with 2 lanes, 2 directions	2,000 (both directions)
Road with 3 lanes, 2 directions	4,000 (both directions)

CARRYING CAPACITY OF EACH ROAD TYPE

Source : Paopong, 1997

The V/C ratio is compared with the standard for traffic classification in the future as shown in **Table 5.1.2.1-3**.

V/C ratio is used to evaluate the impacts on highways and local roads in the surrounding communities and the nearby areas by using the traffic data (as shown in **Table 4.3.2-1** to **Table 4.3.2-2** in **Chapter 4**) in the format of the ratio of passenger car unit (PCU) per daily traffic capacity of road data (as shown in **Table 4.3.2-6** in **Chapter 4**). The result of the transportation impact assessment is presented in the V/C ratio.

The assessment of current traffic conditions before the Project development shows that the current V/C ratio ranged from 0.01-0.16 (2014). It can be seen that all of the highways and roads near the Project site had a high degree of mobility as shown in **Table 5.1.2.1-3**.

TABLE 5.1.2.1-3

STANDARD VALUE FOR CLASSIFICATION OF FUTURE TRAFFIC

Ratio of Traffic Volume (V/C ratio)	Traffic Condition in the Future
0.89-1.00	Extremely traffic jam
0.68-0.88	Traffic jam
0.53-0.67	Fair traffic
0.37-0.52	Good traffic flow
0.20-0.36	Excellent traffic flow

Source : Paopong, 1997

The V/C ratio is calculated by using the following equation:

V/C ratio

Increased traffic volume + current traffic volume

Traffic capacity of each highway and road

During the construction period, an increase in traffic volume will arise from the transportation of equipment and machinery and construction workers and materials. The results of transportation impact in V/C ratio with the estimation of highest traffic volume for each transportation type during the construction period as shown in **Table 5.1.2.1-4** are as follows:

TABLE 5.1.2.1-4

MAXIMUM NUMBER OF VEHICLES EXPECTED DURING THE CONSTRUCTION PERIOD

Transported Item	Vehicle Type	Trip Number	Safety Factor
	(Trip/day)		(10 %)
Devices/machines	Truck with trailer	20	22
Workers	Van or mini-bus	96	106
Materials	Truck with trailer	60	66
Total		176	194

Transportation of Equipment and Machinery

For the transportation of equipment and machinery, 10 trailer trucks will be used, accounted for 20 trips/day (round trip):

- 10 % Safety Factor (20×1.1)	=	22 trips/day
- In the 8 hr/day working scenario		
The traffic volume of the machinery transportation	=	3 trips/hr
- The PCU volume from the Project	=	3×2.0 PCU/hr
	=	6 PCU/hr

Transportation of Construction Workers

There will be up to 3,200 construction workers to be transported with 48 vans and small trucks, accounted for 96 trips/day (round trip):

_	10 % Safety Factor (96×1.1)	=	106 trip	os/day
_	In the 2 hr/day transportation scenario (w	vorke	rs comm	uting in the
	morning and evening only)			
The traffic v	olume of the transportation of workers	=	53	trips/hr
_	The PCU volume from the Project	=	53×1.5	PCU/hr
		=	79.5 PC	U/hr

Transportation of Construction Materials

For the transportation of materials, 30 trailer trucks will be used, accounted for 60 trips/day (round trip):

 10 % Safety Factor (60×1.1) 	=	66 trips/day
 In the 8 hr/day working scenario 		
The traffic volume of the transportation of materials	=	9 trips/hr
- The PCU volume from the Project	=	9×2.0 PCU/hr
	=	18 PCU/hr

However, during the construction period, the transportation of workers will take place in the morning and the evening only, unlike other activities that will take place in all working hours. The Project evaluated the transportation impact in the worst case scenario, where the traffic volume occurred at the same time. Therefore, the increase in traffic volume arisen from the transportation of machinery, workers and materials used in the Project construction will be as follows:

Trailer trucks for machinery transportation	=	6	PCU/hr
Vans/small trucks for worker transportation	=	79.5	PCU/hr
Trailer trucks for material transportation	=	18	PCU/hr

Therefore, when combining all of the increased traffic volumes resulting from the transportation of machinery, workers and materials of the Project construction, the total traffic volume will be (6+79.5+18 PCU/hr)=103.5 PCU/hr

When comparing the increased traffic volume resulting from the transportation of machinery, workers and materials of the Project construction, which is equal to 194 trips/day, or 103.5 PCU/hr in total, with the traffic parameter of each highway and road, the V/C ratio ranged from 0.02-0.19 as shown in **Table 5.1.2.1-5**, meaning that the activities during the construction period will not cause any impact on the level of mobility and traffic conditions of the transportation routes with details as follows:

• National Highway No. 331: At the measuring station of kilometer 12+300, the current V/C ratio is 0.16. With the Project construction activities, the V/C ratio will increase to 0.17, meaning excellent traffic mobility condition. As a result, the impact on the traffic condition of National Highway No. 331 is low.

• Rural Road No. Chor Bor. 3027: The current V/C ratio is 0.01. With the Project construction activities, the V/C ratio will increase to 0.02, meaning excellent traffic mobility condition. As a result, the impact on the traffic condition of Rural Road No. Chor Bor. 3027 is low.

TABLE 5.1.2.1-5

V/C RATIO OF ROADS RELATED TO THE PROJECT IN CURRENT CONDITION

Location	Current	Traffic	Traffic	Number	Road		
	traffic	volume from	volume on	of	capacity	V.	/C ratio
	volume	Construction	roads plus	traffic			
	on roads	period	traffic	lane			
	1/		volume from				
			construction				
			period				
	(PCU/hr.)	(PCU/hr.)	(PCU/hr.)		(PCU/hr.)	Present	construction
National Highway No. 331	1,275	103.5	1,378.5	4	8,000	0.16	0.17
(km. 12+300)							
Rural Road No. Chor Bor.	43	103.5	146.5	4	8,000	0.01	0.02
3027							
National Highway No. 3574	1,174	103.5	1,277.58	4	8,000	0.15	0.16
(km. 4+418)							
Rural Road No. Ror Yor 0403	437	103.5	540.5	2	4,000	0.11	0.14
(km. 0+460)							
(Sunday 2 March 2014)							
Rural Road No. Ror Yor 0403	650	103.5	753.5	2	4,000	0.16	0.19
(km.0+460)							
(Monday 3 March 2014)							

AND DURING CONSTRUCTION PERIOD

Remark : ^{1/} Current Traffic Volume (PCU/hr.) is data on 2014

V/C ratio :

0.89-1.00 = Extremely traffic jam 0.53-0.67 = Fair traffic flow 0.20-0.36 = Excellent traffic flow

0.68-0.88 = Traffic jam 0.37-0.52 = Good traffic flow

• National Highway No. 3574: At the measuring station of kilometer 4+418, the current V/C ratio is 0.15. With the Project construction activities, the V/C ratio will increase to 0.16, meaning excellent traffic mobility condition. As a result, the impact on the traffic condition of National Highway No. 3574 is low.

• Rural Road No. Ror Yor. 0403: At the measuring station of kilometer 0+460, on Sunday 2 March 2014, the current V/C ratio was 0.11. With the Project construction activities, the V/C ratio will increase to 0.14, meaning excellent traffic mobility condition. On Monday 3 March 2014, the current V/C ratio is 0.16. With the Project construction activities, the V/C ratio will increase to 0.19, meaning excellent traffic mobility condition, too. As a result, the impact on the traffic condition of Rural Road No. Ror Yor. 0403 is low.

(2) Operation Period

After the launch of the project, the transportation impact may occur as a result of the commutation of power plant employees, transportation of sediments arisen from the initial water naturalization system, and transportation of chemicals. Details of traffic volume during the operation period as shown in **Table 5.1.2.1-6** are as follows:

TABLE 5.1.2.1-6

MAXIMUM NUMBER OF VEHICLES EXPECTED DURING THE OPERATION PERIOD

Transported Item	Vehicle Type	Vehicle Number (Car/day)	Trip Number (Trip/day)
Commutation of Power Plant Employees	Passenger car	60	120
Transportation of Sediments from Water	Truck	1	2
Pre-treatment System			
Transportation of Chemicals	Truck with trailer	1	2
Total		62	124

Commutation of Power Plant Employees

There will be up to 60 employees working at the power plant. For the worst case scenario where all of them were commuting by cars and working at the same time, there will be 60 personal cars, accounted for 120 trips/day (round trips):

- 10 % Safety Factor (120×1.1) = 132 trips/day
- In the 2 hr/day transportation scenario (employees commuting in the morning and evening only)

The traffic volume of the commutation of employees = 66 trips/hr

The PCU volume from the project = 66 × 1.0 PCU/hr

= 66 PCU/hr

Transportation of Sediments from Water Pre-treatment System

There will be up to 5 tons of sediments per day arisen from the initial water naturalization system, requiring a 10-wheel truck to transport them for disposal, three times per week. For the worst case scenario of daily disposal, there will be one 10-wheel truck, accounted for 2 trips/day (round trips):

-	10 % Safety Factor (2×1.1)	= 3 trips/day
_	In the 8 hr/day working scenario	

- The traffic volume of the transportation of sediments = 1 trips/hr
- The PCU volume from the project = 1×2.0 PCU/hr

= 2 PCU/hr

Transportation of Chemicals

In terms of the chemicals needed for the operation of the power plant, there will be up to 140 trips/yr, requiring a trailer truck, or on the average of 3 trips/week. For the worst case scenario of daily transportation, there will be one trailer truck, accounted for 2 trips/day (round trips):

-	10 % Safety Factor (2×1.1)	=	3	trips/day
_	In the 8 hr/day working scenario			
The	e traffic volume of the transportation of chemicals	=	1	trips/hr
_	The PCU volume from the project	=	$1 \times$	2.0 PCU/hr
		=	2	PCU/hr

Therefore, during the operation period, the increased traffic volume that may occur as a result of the commutation of employees and transportation of sediments from water pre-treatment system and chemicals will be equal to 70 PCU/hr. This increased traffic volume resulting from the Project operation, together with the traffic parameter of each highway and road, was calculated to find the V/C ratio. It shows that the V/C ratio ranged from 0.01-0.18 (**Table 5.1.2.1-7**), meaning that the activities during the construction period will not cause any impact on the level of mobility and traffic conditions of the transportation routes with details as follows:

• National Highway No. 331: At the measuring station of kilometer 12+300, the current V/C ratio is 0.16. With the Project operation activities, the V/C ratio will increase to 0.17, meaning excellent traffic mobility condition. Thus, the impact on the traffic condition of National Highway No. 331 is low.

• **Rural Road No. Chor Bor. 3027:** The current V/C ratio is 0.01 while the Project operation activities did not change the V/C ratio, remaining at 0.01, meaning excellent traffic mobility condition. As a result, the impact on the traffic condition of Rural Road No. Chor Bor. 3027 is low.

• National Highway No. 3574: At the measuring station of kilometer 4+418, the current V/C ratio is 0.15. With the Project operation activities, the V/C ratio will increase slightly to 0.16, meaning excellent traffic mobility condition. As a result, the impact on the traffic condition of National Highway No. 3574 is low.

• **Rural Road No. Ror Yor. 0403:** At the measuring station of kilometer 0+460, on Sunday 2 March 2014, the current V/C ratio was 0.11. With the Project operation activities, the V/C ratio will increase to 0.13, meaning excellent traffic mobility condition. On Monday 3 March 2014, the current V/C ratio was 0.16. With the Project operation activities, the V/C ratio will increase to 0.18, meaning excellent traffic mobility condition, too. As a result, the impact on the traffic condition of Rural Road No. Ror Yor. 0403 is low.

TABLE 5.1.2.1-7

V/C RATIO OF ROADS RELATED TO THE PROJECT IN CURRENT CONDITION

Location	Current	Traffic	Traffic volume	Number	Road		
	traffic	volume from	on roads plus	of traffic	capacity	V/C ratio	
	volume	operation	traffic volume	lane			
	on roads	period	from operation				
	1/		period				
	(PCU/hr)	(PCU/hr)	(PCU/hr)		(PCU/	present	operation
					hr)		
National Highway No. 331 (km.	1,275	70	1,345	4	8,000	0.16	0.17
12+300)							
Rural Road No. Chor Bor. 3027	43	70	113	4	8,000	0.01	0.01
National Highway No. 3574	1,174	70	1,244	4	8,000	0.15	0.16
(km. 4+418)							
Rural Road No. Ror Yor 0403	437	70	507	2	4,000	0.11	0.13
(km. 0+460)							
(Sunday 2 March 2014)							
Rural Road No. Ror Yor 0403	650	70	720	2	4,000	0.16	0.18
(km.0+460)							
(Monday 3 March 2014)							

AND DURING OPERATION PERIOD

Remark : ^{1/} Current Traffic Volume (PCU/hr.) is data on B.E.2557.

V/C ratio :

0.53-0.67 = Fair traffic flow 0.20-0.36 = Excellent traffic flow

0.89-1.00 = Extremely traffic jam 0.68-0.88 = Traffic jam 0.37-0.52 = Good traffic flow

Mitigation Measures

(1) Construction Period

- Plan for the routes to be used for transportation of construction materials and equipment of the project to avoid traffic problems.
- Review and adjust the route plans for the transportation of construction materials and equipment of the project regularly to adapt to the current situation.
- Avoid transporting construction materials during the rush hours, such as between 07.30 - 08.30 hrs. and between 16.00-17.00 hrs. to alleviate problems of traffic congestion. If transporting during those hours is necessary, seek approval from the relevant agencies and notify the community at least two weeks in advance.
- Cover up all trucks completely with canvas to prevent materials from falling on road surface.

• Ensure that all contractors order their drivers to strictly comply with the traffic rules.

- Control of the trucks' weight not to exceed the legal limits.
- Provide training and control drivers to comply with traffic rules strictly.
- Inspect and maintain the vehicles used in the project, regularly.

• Coordinate with traffic police in the area of the transportation of various materials and equipment.

• Limit the truck's speed on the highway not to exeeding 80 kilometers/hour in accordance with the Land Transportation Act B.E. 2522 and the Highway Act No. 2 and No. 3 B.E. 2542. Limit the speed at 40 kilometers/hour in the community zone.

• Install speed limit sign displaying the limit within the construction area not to exceeding 20 kilometers/hour.

• Display the telephone number of the person in charge of the delivery vehicles as a channel to notify or complain to the project.

• Provide security personnel to facilitate the entry into and exit from the project.

(2) Operation Period

• Require all driver to strictly follow traffic rules.

• Establish rules of transportation and rules of safety for vehicles entering and exiting the project to prevent accidents.

• Provide sufficient parking spaces within the project at the suitable locations. Install various traffic signs in the area of construction and along the route leading to the project.

• Install signs limiting speed in the project area to no more than 20 kilometers/hour.

• Limit the vehicles entering the production units to reduce accident in the production units.

• Record the type and number of cars entering the project area and use such information to manage traffic within the project area. Strictly prohibit parking outside the designated areas.

• Inspect the condition of the transportation vehicles regularly.

• Display of the telephone number of the person in charge of the delivery vehicles as a channel to notify or complain to the project.

• Ensure that the companies delivering chemicals and companies approved for transportation of solid waste comply with the relevant laws (e.g. Ministry of Industry's Notification re: Delivery Documentary System for Transportation of Hazardous Substances B.E.2547", Ministry of Industry's Notification re: Land Transportation of Hazardous Substances B.E.2546, the Land Transportation Department's Notification re: Installation of Signs of Characters, Pictures and Symbols on Trucks Transporting Hazardous Substances, etc.).

• Require trucks transporting chemicals and trucks transporting solid waste to show warning signs. The signs must be clear and easy to understanding specify the name and details of the chemicals in accordance with the international standards, such as, UN Suggestions, HAZCHEM codes, etc.

5.1.2.2 Water Use

(1) Construction Period

Regarding the activities that require water during the construction period, the contractors will supply water for the workers' consumption as well as for the construction activities. This includes:

(a) Water for construction and workers' consumption of 224 m³/day (estimated from the water use of 70 L/person/day (Kriengsak, 1996) with the maximum number of 3,200 construction workers) will be provided by the contractor, including bottled water for drinking

(b) Water for the Project construction activities of 55 m^3/day

(c) Water for spraying the area to reduce dust in the Project site during the construction period of 1,058 m³/day (based on the rate of single spray/time of 0.75 L/m^2 , two times per day for the area of 441 rai).

Regarding the hydrostatic test for the diesel pipelines and natural gas pipelines of 250 m³, this will be supplied by Hemaraj ESIE.

Total volume of water to be used during the construction of Sriracha Power Plant is 1,337 m³/day. This will not cause any impact on the water use for people living in the surrounding communities.

(2) Operation Period

During the operation period, the Project will need water for cooling system and production activities (consisting of discharged water from water naturalization system, discharged water from laboratory, and discharged water from office buildings) with the maximum usage of 63,000 m³/day. The water will be supplied by Hemaraj ESIE, who receives the water from Eastern Water Resources Development and Management Plc. at the average of 95,996 m³/day, including the amount to be supplied to the Project (according to the Report on the Amendment of the Project Details in the Environmental Impact Assessment of Hemaraj ESIE, No. 2). Hemaraj ESIE needs raw water of 32,658 m³ daily for production of its water supply system with the capacity of 30,000 m³/day. This means that the remaining volume after supplying to the Project (32,996 m³/day) is sufficient for production of water supply. Therefore, this will not cause any impact on the water usage of other premises in Hemaraj ESIE. In addition, the water for the Project's use comes from different sources used by the community. As a result, this will also not have any impact on the water use for local residents.

Mitigation Measures

(1) Construction Period

• Require contractors to supply adequate water for use in the construction activities.

• Require the contractors to provide adequate and hygienic drinking water for construction workers.

• Require the contractors to coordinate with the estate to allocate water for the hydrostatic test.

(2) Operation Period

• Consider ways to increase the efficiency of water usage, such as, reduction of water draining from the cooling system or recycling water within the project for maximum benefits.

• Inspect condition of water pipes and repair leakages immediately to prevent loss of water.

• Reduce power production or halt operation in case of water shortage where the estate cannot supply water to the project.

5.1.2.3 Water Drainage and Flood Control

(1) Study Method

Stormwater runoff is calculated using the rational formula (Thongchai, 1991) to find the volumes of flood water in small catchment area and runoff. As the catchment area of the Project is less than 25 km² as shown in **Table 5.1.2.3-1**, the calculation uses the following equation:

	Q	=	0.278 × 10 ⁻⁶ CIA (1)
Where	Q	=	Peak runoff rate (m ³ /s)
	С	=	Coefficient of runoff
	I	=	Intensity of rainfall (mm/hr)
	А	=	Stormwater catchment area (m ²)

• Coefficient of Runoff (C)

The calculation of coefficient (C) of runoff takes into account the guidelines proposed by Environmental Engineering Association (2003) who has compiled and specified the surface runoff coefficient according to the characteristics of the surface of watershed areas and land use (as shown in **Table 5.1.2.3-2** and **Table 5.1.2.3-3**). Details are as follows:

• Before the Project Development

The total area before the Project development is 705,600 m². The current condition is a vacant land leveled and filled for further use, without any building, which is classified as the least developed or unimproved area. Therefore, the coefficient of runoff is estimated at 0.03 (unimproved areas).

• After the Project Development

The areas after the Project development consist of uncontaminated stormwater catchment areas and contaminated stormwater catchment areas as shown in **Table 5.1.2.3-1**:

TABLE 5.1.2.3-1

STORMWATER CATCHMENT PROJECT AREAS

	Components Within the Project Area	Estimated Area (m ² .)	
(1)	Uncontaminated stormwater catchment areas		
	Areas with concrete pavement or roofs		
	– Power Block	67,600	
	– Gas Metering Station	6,100	
	– Gas Compressor	1,600	
	– Cooling Water Area	24,200	
	– Control Building	1,000	
	- Workshop & Warehouse Building	1,200	
	 Administration Building and Guard House 	800	
	 Water Treatment and Wastewater Treatment Area 	26,200	
	- Other areas such as water discharging canal, pipe lining area, right of	289,341	
	Way for electricity transmission line, etc.		
	Areas without concrete pavement or roofs		
	– Green Area	35,300	
	 Vacant areas without development 	137,773	
	Pond Area		
	– Raw Water Pond	43,300	
	– StormWater Pond	43,200	
	Total (1)	677,614	
(2)	Contaminated stormwater catchment areas		
	Areas with concrete pavement or roofs		
	– Diesel Storage Tank Area	6,726	
	– Transformer	1,560	
	Pond Area		
	 Cooling Water Holding Pond 	19,600	
	 Wastewater Holding Pond 	100	
	Total (2)	27,986	
	Grand Total (m².)	705,600	

Source : Gulf SCR Co., Ltd., 2015

TABLE 5.1.2.3-2

Character of Surface	Runoff Coefficients
Pavement	
- Asphalt or concrete	0.70-0.95
– Brick	0.70-0.85
Roofs	0.75-0.95
Lawns, sandy soil	
- Flat (2 %)	0.05-0.10
- Average (2 to 7 %)	0.10-0.15
- Steep (>7 %)	0.15-0.20
Lawns, heavy soil	
- Flat (2 %)	0.13-0.17
- Average (2 to 7 %)	0.18-0.22
- Steep (>7 %)	0.25-0.35

RUNOFF COEFFICIENT OF CHARACTER OF SURFACE

Source : Environment Engineering Association of Thailand, 2003.

TABLE 5.1.2.3-3

RUNOFF COEFFICIENT OF CHARACTER OF LAND USE

Character of Land Use	Runoff Coefficients				
Business					
- Downtown	0.70-0.95				
- Neighborhood	0.50-0.70				
Residential					
- Single Family	0.30-0.50				
- Multi-units, detached	0.40-0.60				
- Multi-units, attached	0.60-0.75				
Residential (suburban)	0.25-0.40				
Apartment	0.50-0.70				
Industrial					
– Light	0.50-0.80				
- Heavy	0.60-0.90				
Park, Cemeteries	0.10-0.25				
Playgrounds	0.20-0.35				
Railroad yards	0.20-0.35				
Unimproved	0.10-0.30				
Source : Environment Engineering Association of Thailand, 2003.					

(a) Uncontaminated stormwater catchment areas include:

- Areas with concrete pavement or roofs, such as buildings, electricity generation area, and road, etc., of 128,700 m² in total, with the runoff coefficient of 0.90 (areas with asphalt or concrete paving);

- Areas with concrete pavement or roofs, such as buildings, electricity generation area, and road, etc., of 289,341 m² in total, with the runoff coefficient of 0.85 (areas with roofs);

- Areas without concrete pavement or roofs, such as green areas, of 35,300 m², with the runoff coefficient of 0.25 (park areas);

- Vacant areas without development of 137,773 m², with the runoff coefficient of 0.30 (unimproved areas).

In this regard, the average runoff coefficient of the areas can be calculated using the following equation:

	С	=	$[(C_1 \times A_1) + (C_2 \times A_2) + \dots + (C_1 \times A_1)] / \sum A \dots (2)$
Where	С	=	Average runoff coefficient
C ₁	, C ₂ ,, C _n	=	Runoff coefficient of stormwater catchment areas
			A ₁ , A ₂ ,, A _n
A ₁ , ,	A ₂ ,, A _n	=	Stormwater catchment areas A_1 , A_2 ,, A_n (m ²)

 ΣA = Total stormwater catchment areas (m²)

Therefore, the average runoff coefficient of uncontaminated stormwater catchment areas is equal to:

C = [(0.9×128,700) + (0.85×289,341) +(0.25×35,300) + (0.3×137,773)]/591,114 C = 0.7

- The raw water pond and stormwater retention pond have the size of 43,300 m² and 43,200 m² respectively. Since the runoff of the stormwater in those areas falls directly into the ponds and does not flow into the stormwater drainage gutter, this rate will not be included in the calculation of the average runoff coefficient of uncontaminated storm water catchment areas. The total runoff coefficient is 1.00.

(b) Contaminated stormwater catchment areas include:

- Areas with concrete pavement or roofs, such as diesel storage tanks and transformers, etc., of 8,286 m², with the runoff coefficient of 0.90 (areas with asphalt or concrete paving or with roofs);

- Pond areas, including discharged water retention pond and cooling blowdown, of 19,700 m², with the runoff coefficient of 1.00.

• Return Period

The return period is an estimate of the likelihood of rainfall of the same volume or more to repeat. According to the standard for stormwater drainage gutter design proposed by the Royal Irrigation Department, the rainfall return period is equal to 10 yr. This number is used for the hydrological calculation for the area before the development of the Project and the design of stormwater collection and drainage system of the Project since the site is in the industrial estate and the area has already been prepared.

Runoff Time

In determining the runoff duration for the design of stormwater pond and drainage gutter system for the areas after the development of the Project according to the guidelines proposed by Environmental Engineering Association of Thailand (2003), details are as follows:

Areas before the Project development: a vacant land that has been leveled and filled, without any building, classified as the least developed or unimproved area, mostly flat or the least slope, the runoff duration is estimated to be 20-30 min. Therefore, the runoff time to the drainage point of the Project before the development is 30 min or 0.50 hr

Areas after the Project development: most of the areas are developed into building and areas with coverage such as roads, preventing the runoff to infiltrate into the ground. Although the areas are well developed, the surface is mostly flat or the least slope. Thus, the runoff time to the drainage point can be estimated to be 10-15 min. Therefore, the runoff duration of the Project after the development is 15 min or 0.25 hr.

Rainfall Intensity

The rainfall intensity (I) can be specified from the relationship between the rainfall intensity (I) and the rainfall duration, or equal to the runoff time (Tc) by determining the required return period. Regarding the Project site, as the local rain station is not available in the Project area, the nearest station, which is Rain Station Z.4 in Pluak Daeng District, Rayong Province, will be use as a reference. However, since Rain Station Z.4, Pluak Daeng, has the data of rainfall intensity measured up to 1988 (1967-1988) only, the Project therefore decided to use rainfall data from Rayong Rain Station, which has been measuring

and keeping records of rainfall data since 1990 until 2011 (the Meteorological Department, 2014) as the representative of Pluak Daeng Rain Station in the calculation using Gumbell method (**Figure 5.1.2.3-1**). When determining the return period equal to 10 yr and the runoff time to the stormwater drainage gutter and pond equal to 0.25 and 1.00 hr, the rainfall intensity can be specified as follows:

- For the return period of 10 yr and the runoff time of 0.25 hr, the rainfall intensity (I) will be at 116.22 mm/hr.

- For the return period of 10 yr and the runoff time of 0.50 hr, the rainfall intensity will be at 82.85 mm/hr. However, in order that the evaluation and design of stormwater pond of the Project can be the most comprehensive, the Project used the volume of 116.22 mm/hr as the rainfall intensity of both before and after the Project development.



Source : The rainfall data from Rayong Rain Station has been measuring and keeping records of rainfall data since 1990 until 2011 (the Meteorological Department, 2014). Analyze by Team Consulting Engineering and Management Co., Ltd., 2014.



(2) Study Results

(a) Construction Period

The area condition before the Project development is an industrial area that had been leveled and filled, an unimproved area, without any building, having the runoff coefficient of 0.3 and the peak runoff rate of 6.83 m³/s (details are as shown in **(b) Operation Period**). After the development of the project, the area condition is changed into the areas with asphalt or concrete paving, green areas, raw water pond and stormwater ponds, with an increase in the average runoff coefficient and the peak runoff rate of 14.56 m³/hr (details are as shown in **(b) Operation Period**). This increase in the runoff volume is according to the construction plan of the project.

In this regard, the Project has designed the stormwater drainage systems separately between the contaminated and uncontaminated stormwater along the roadside and around the buildings. In addition, the Project has also established the inspection ponds before discharging into Hemaraj ESIE's rainwater drainage system. This rainwater drainage gutter will subsequently be improved into the more permanent type with reinforced concrete drainage gutter during the operation period.

Furthermore, when considering the capacity of Hemaraj ESIE for stormwater collection and drainage, the peak runoff rate is 15.03 m³/hr. Therefore, it can be concluded that Hemaraj ESIE's stormwater drainage system can handle all of the runoff volume that may occur inside the Project site. As a result, this will not cause any impact on the surrounding areas.

(b) Operation Period

(b.1) Uncontaminated Stormwater Catchment Areas Before the Project Development

The area condition before the Project development is an industrial area that has been leveled and filled, without any building, having the runoff coefficient of 0.3 (unimproved area). The uncontaminated stormwater catchment area of 705,600 m² can be calculated to find the runoff rate as follows:

> Peak runoff rate = $0.278 \times 10^{-6} \times 0.3 \times 116.22 \times 705,600$ = 6.83 m³/s = 24,601 m³/hr

After the Project Development

The uncontaminated stormwater catchment areas of the Project cover the areas of electricity generation and other supporting systems, including buildings, roads, green areas, vacant and unimproved areas, and ponds. The runoff rate can be calculated as follows:

The total area of the electricity generation and other supporting systems is 591,114 m², having the average runoff coefficient equal to 0.7 (areas with concrete pavement/roofs and areas without concrete pavement/roof).

Peak runoff rate	=	0.278 × 10 ⁻⁶ ×0.7×116.22×582,640
	=	13.30 m ³ /s
	=	47,874 m ³ /hr

Rainwater retention pond areas (runoff coefficient equal to 1.00)

Peak runoff rate	=	$0.278 \times 10^{-6} \times 1.00 \times 116.22 \times 43,200$
	=	1.39 m³/s
	=	5,021 m ³ /hr
Raw wat	er pono	d areas (runoff coefficient equal to 1.00)

Peak runoff rate = $0.278 \times 10^{-6} \times 1.00 \times 116.22 \times 43,300$ = $1.40 \text{ m}^3/\text{s}$ = $5,032 \text{ m}^3/\text{hr}$

Since stormwater falls into the raw water and discharged water from production activities ponds directly, this will not be included in the calculation for the design of the Project's drainage system. Therefore, the total runoff rate of uncontaminated stormwater after the Project development will be at 14.69 m³/s, or 52,884 m³/hr.

Changes in the Runoff Rate Before and After the Project Development

When considering the changes in the runoff rate of uncontaminated stormwater before and after the Project development, it can be seen that the runoff rate of uncontaminated stormwater increases about 7.86 m³/s, or 27,819 m³/hr. Since the majority of the area after the Project development is the graded land and concrete pavement, the runoff rate subsequently increases. Therefore, it is essential to retain the stormwater to reduce the impact on hydrological conditions outside of the Project site, with the retention time of at least 3 hr. The calculation of the volume of the retention pond is as follows:

	∨ =	Qt(2)
where	V =	Volume of the stormwater pond, m ³
	Q =	Runoff rate for retention, m ³ /hr (28,290 m ³ /hr)
	t =	Time for runoff retention, hour (3 hr)
Therefo	ore,	

 $v = 28,290 \text{ m}^3/\text{hr} \times 3 \text{ hr}$

= 84,870 m³

Regarding the three stormwater ponds with the total volume of 89,469 m³, they can hold all of the stormwater runoff inside the Project site without any spill over to the outside. Based on the capacity of Hemaraj ESIE for stormwater collection and drainage with the peak runoff rate is 15.03 m³/hr (**Appendix 3J**), it can be concluded that Hemaraj ESIE's stormwater drainage system can handle all of the runoff rate inside the Project site. As a result, this will have no impact on the vicinity.

(b.2) Contaminated stormwater catchment areas Before the Project Development

The area conditions before the Project development is industrial area that has been leveled and filled but without any building and activities that may be contaminated with oil. Therefore, all of rainfall inside the Project site is the uncontaminated stormwater.

After the Project Development

The contaminated stormwater catchment areas of the Project cover the areas with concrete pavement or roofs (diesel storage tanks and transformers) and pond areas (discharged water retention pond and cooling blowdown). The runoff rate can be calculated as follows:

Areas with concrete pavement/roofs (runoff coefficient equal to 0.90)

Peak runoff rate = $0.278 \times 10^{-6} \times 0.90 \times 116.22 \times 8,286$

 $= 0.24 \text{ m}^3/\text{s}$

Pond areas (runoff coefficient equal to 1.00)

Peak runoff rate = $0.278 \times 10^{-6} \times 1.00 \times 116.22 \times 19,700$

Since stormwater falls into the ponds directly, this will not be included in the calculation for the design of the Project's drainage system. Therefore, the total runoff rate of contaminated stormwater of the Project will be equal to 0.24 m³/s, or 867 m³/hr. For the oil contaminated areas, including diesel storage tanks and transformers, there are stormwater dikes with the capacity of 11,127 m³, which can hold stormwater more than the 24 hr accumulated volume, which is equal to 734.83 m³ (details of the calculation are as shown in **Appendix 3L**). Such contaminated stormwater will be gradually transported to the water/oil separator tank, which is able to treat the oil contaminated water to have the oil contamination level of less than 5 ppm (**Appendix 3L**). As a result, this will have no impact on the surrounding areas.

Mitigation Measures

(1) Construction Period

• Collect and sort scrap materials and refuse from construction activities and send them to the company licensed by the government for disposal in order to prevent them from clogging the water draining route of the project.

• Design an appropriate rainwater drainage system to prevent obstruction to existing waterways and flooding in the vicinity.

• Prohibit discarding of refuse and scrap materials in the water drainage gutters.

• Keep checking the water drainage gutters regularly to prevent clogging.

(2) Operation Period

• Connect rainwater drainage gutters in the project areas to the rainwater draining systems of Hemaraj Eastern Seaboard Industrial Estate.

• Provide Stormwater Pond with total holding capacity of not less than 86,592 m³ capable of holding rainwater for three hours in order to control the rate of water flowing out of the project area to a suitable level to prevent flooding in the project area.

• Drain contaminated rainwater to the Oil Separator pond to separate oil from water. Then drain uncontaminated water into the waste pond for inspection of the discharged water quality to ensure it meets the standard established by the estate before draining into the central wastewater treatment system of Hemaraj Eastern Seaboard Industrial Estate.

• Inspect water drainage gutters in the project area regularly to prevent any clogging.

• Clean water drainage gutters during the dry season each year to increase efficiency of the water drainage system.

• Support the responsible agency of Khlong Kram and Khlong Rawoeng in the dredging of those canals

5.1.2.4 Waste Management

(1) Construction Period

During the construction period, it is estimated that the maximum of 3,200 construction workers will be mobilized. The garbage generated includes plastic, paper, glass bottles, plastic bottles, etc. which are classified as general solid waste. Therefore, it is estimated that the quantity of solid waste generated during the construction period is approximately 2,720 kg/day (estimated from the average amount of garbage generated of 0.85 kg/person/day, ref. Kriengsak Udomsinroj, 1994). The contractor is required to provide at least 46 garbage containers of 200-L capacity (garbage density of 0.3 kg/L) with proper covers to collect such wastes and place them inside the construction area and around the field office. The contract will specify that the contractor shall collect and dispose this garbage.

Wastes/garbage resulting from construction activities include debris from land excavation including dirt, broken bricks, etc.; wastes from construction materials, including debris from structure parts or used materials and wastes, etc.; and, hazardous wastes, including used batteries, motor oil, hydraulic oil, filters, mineral oil, cleaning agents, or used solvents, as well as defected coating products and paints, etc. The project has provided specific area for storing garbage and each type of solid wastes separately, and used suitable containers for collecting each type of solid wastes. The recyclable wastes will be reused and recycled or sold to waste buyers. The hazardous wastes will be collected and further disposed by the company authorized by the Department of Industrial Works.

Therefore, it can be estimated that the construction of the Project will not cause any impact of solid waste management on the surrounding communities.

(2) Operation Period

During the operation period, solid wastes generated by the Project consist of two types: discarded materials exempt from the approval for transportation out of the factory grounds; and, those without such exemption according to Ministry of Industry's Notification B.E. 2548 re: Disposal of Garbage or Discarded Materials. The project has set up the management measures as follows:

(a) Discarded materials exempt from the approval for transportation out of the factory grounds:

General garbage pursuant to Public Health Act B.E. 2535 includes scrap paper, waste materials, and leftover food. With the maximum of 60 employees, it is estimated that the amount of garbage generated will be 51 kg/day (estimated from the average quantity of garbage generated of 0.85 kg/person/day, ref. Kriengsak Udomsinroj, 1994). The garbage will be collected in the bins with proper lids and handled/transported for disposal by the local authorities or authorized companies.

(b) Discarded materials required to seek an approval for transportation out of the plant according to Ministry of Industry's Notification B.E. 2548:

• Used lubricating oil and oil from oil/water separators: the quantity of used lubricating oil is estimated to be 800 L/month which is collected in 200-L steel drums and stored in the Project's hazardous waste storage facility prior to the transport for further disposal by the industrial waste management company authorized by the Department of Industrial Works.

• Used resins: Each year, the quantity of used resins that need replacement are estimated to be approximately 1 m³/yr. This amount will be returned to the manufacturer or separately collected in plastic bags in 200-L oil drums and subsequently transported for disposal by the industrial waste management company authorized by the Department of Industrial Works.

• Used air filters: The air filters prevent dust to get through to the gas turbines otherwise the efficiency of gas turbines will decline. The air filters need to be replaced according to their lifetime of 1.5 yr. The quantity of used air filters is estimated to be 4,704 pieces/1.5 yr which will be separately collected and stored in the gas turbine

building by the Project and subsequently transported for disposal by the industrial waste management company authorized by the Department of Industrial Works.

• Sludge from Water Pre-treatment System: The water pretreatment system separates sediments from raw water. The quantity of sediments resulting from this water treatment is about 5 tons/day. The generated sludge is collected in the sludge hoppers and stored inside the water pre-treatment building and subsequently transported for disposal three time per week by the industrial waste management company authorized by the Department of Industrial Works.

Regarding the waste management during the operation of the project, the procedures are in accordance with Ministry of Industry's Notification B.E. 2548 re: Disposal of Garbage or Discarded Materials as well as other related regulations prescribed by the government. In addition, the collection, storage and transportation, including the facilities responsible for the disposal are handled by the industrial waste management organization authorized by the Department of Industrial Works. Therefore, it can be estimated that the operation of the Project will cause low impact on solid waste management.

Mitigation Measures

(1) Construction Period

• Assign workers to collect refuse in the designated area at least once a day.

• Deliver hazardous waste to the company licensed by the government for disposal as prescribed in Ministry of Industry's Notification re: Disposal of Refuse or Discarded Materials, B.E.2548.

• Provide refuse bins for collection of refuse with well covered lids and coordinate with the company licensed by the government to collect refuse for disposal.

• Collect, store, and dispose of scrap materials, earth debris and refuse from construction by appropriate means.

• Control management of oil from the project such as the engine oil changes and construction equipment. Collect the oil in the tanks for delivery to the company licensed by the government for disposal.

• Ensure that construction workers dispose solid waste in the bins and empty the bins regularly.

- Allocate appropriate areas for stock yard.
- Strictly prohibit the burning of refuses.

• Sort refuses and reusable scrap materials such as, wooden scraps, scrap iron, bricks, paint tins, paint brushes, spray cans and recycle them or reuse or sell them to the buying companies.

• The contractors must coordinate with the local municipality or government agency to collect the refuse in order to prevent the refuse from accumulating in the project area which will be a source of disease and foul smells.

(2) Operation Period

• Provide collection bins for refuse with secure lids in sufficient number for collection of solid waste from the project for delivery to the company licensed by the government for disposal by mean specified by law.

• Provide the place for collection of refuse and solid waste which is covered by a roof and has concrete floor. Separate the types of the waste and install clear sign boards.

• Collect and use recyclable refuses from the project as much as possible or sell them to the buying companies. Deliver the remainder to the company licensed by the government for disposal in accordance with Ministry of Industry's Notification re: Disposal of Refuse or Discarded Materials B.E. 2548.

• Separate hazardous solid waste of characteristics prescribed with Ministry of Industry's Notification re: Disposal of Refuse and Discarded Materials B.E.2548 such as lubricant and solvent from cleaning tools from general refuses for disposal by the company licensed by the government.

• Provide bins/tanks with securely closed lids for collection of solid waste from the production process, such as resin, oil, etc. to be delivered for selling to companies licensed by the government for disposal.

• Record type, and quantity of solid waste produced and the destination to which they are transported for sale or disposal.

5.1.3 QUALITY OF LIFE

5.1.3.1 Socio-Economics

The social impact assessment (SIA) has been applied for the impact assessment on socio-econoomic. The focus is on human utilization values of quality of life (from EIA) and worried issues of people. Consideration was based on secondary data collected from governmental offices, references and results of people's opinions derived from the interview of communities' leaders and families of the target groups. Consideration was also extended to review results of community life styles of people and the forecast of impacts from the project implementation that might cause impacts on society, life style of people in communities, careers, daily life and overall adaptation of members in societies (US Dept of Commerce 1994). The assessment was carried out at the significant level of impacts on social environments (impact occurrence probability + duration + boundary + severity) to be occurred along the steps of the project development in order to propose preventive and mitigation measures together with monitoring the impacts to be relevant to environmental context of communities.

All phases of project development lead to negative and positive impacts directly on local communities. The survey on overall socio-economic status during the Project development phase can be summarized as follows (**Table 5.1.3.1-1**):

• Psychological (information/experience), physical and social (way of living/quality of life) aspects base on the following principles or criteria:

- Pre-construction period: consider concerns about potential environmental impacts of the Project development, including project location, project details, and fuel for electricity generation of the project. These are variables that have a direct effect and significance on the concerns of the community.

- Construction period: consider the socio-economic survey results on concerns about potential environmental impacts of the project development, including air quality, nuisance, water usage, and solid waste management, etc.

- Operation period: consider the socio-economic survey results on concerns about potential environmental impacts of the project operation.

TABLE 5.1.3.1-1

SUMMARY OF OVERALL SOCIO-ECONOMIC IMPACTS

DURING PROJECT DEVELOPMENT PERIOD

	Impacts During Project Development Period					
Socio-economic Impacts	Pre-construction		Construction		Operation	
	Positive	Negative	Positive	Negative	Positive	Negative
Psychological (information/experience)						
- Concerns		✓		✓		✓
- Creditability		✓				
• Physical						
- Air noise pollution/noise nuisance				✓		✓
- Water pollution/aquatic ecology				✓		✓
- Water usage				✓		✓
- Solid waste management				\checkmark		✓
 Social (way of living/quality of life) 						
- Socio-cultural conflict						
\Rightarrow Population growth/decline; migration;				\checkmark		
demographic shifts						
\Rightarrow Social relationships; social problems,				\checkmark		
crimes or other; community						
development, e.g. expansion cities,						
social service facilities, or level of						
urbanization						
\Rightarrow Culture; living/way of life, changing				\checkmark		
lifestyles; faith or others						
- Community economy (employment / local			\checkmark		\checkmark	
revenues)						
- Public health and safety				✓		✓
- Community benefits (Power Development			\checkmark		\checkmark	
Fund)						
- Knowledge enhancement in the					\checkmark	
community (Power Plant Visit)						
Public Participation (role/channel)	1					
- Public policy (Community Relations)						
\Rightarrow Quality of Life Development Project	✓		✓		 ✓ 	
to change and/or improve the quality						
of life of people						

• Public participation (role/channel) aspects base on the following principles:

- Pre-construction period: The project has informed the local communities about the project details to reduce concerns on the project development. In addition, outreach programs have been arranged constantly to show the project's responsibility on community, society and environment as well as to benefit the studied communities and to engage them in the operation of the project. These corporate social responsibility events cover activities that meet the needs of the community, including support on sports, personnel training and development, festivals and traditions, programs for children/children with disabilities and the underprivileged persons, etc. In addition, community relations events have also been arranged in the form of two-way communication to exchange ideas and suggestions between the communities and the project, including the power plant visit, with the objective to create the learning process from direct experience of the target population which will contribute to a better understanding and a reduce in the concerns from the Project operation. As a result, community relations activities will create positive impacts during the Project development before the construction.

- Construction period: Community relations activities have been arranged consistently. In addition, community outreach has been conducted to meet and talk with people in the areas to inquire about the potential impacts that may arise as a result from the Project operation and to take action to alleviate the problem when found occurring to those affected. In addition, channels to receive complaints during the Project construction have been provided so that those affected can report their inconvenience to the project (**Figure 5.1.3.1-1** and **Figure 5.1.3.1-2**). As a result, community relations activities will create positive impacts during the Project development in the construction period.

- Operation Period: The project will continue the community relations activities as well as organizing community outreach programs to return benefits to society. Community relations staff from the project will conduct the area survey and meet and discuss with community leaders to hear their feedbacks about the impact of the Project development during the operation period and to ask about the community requirement or needs for further consideration to provide supports or participation with the community accordingly. Therefore, community relations activities will create positive impacts for the Project development during the operation period.



*Note: "Reporting progress in resolving the problems to the complaining party every 7 days or as agreed.

FIGURE 5.1.3.1-1: SCHEME OF OPERATION ON SRIRACHA POWER PLANT PROJECT'S COMPLAINT RECEIVING



FIGURE 5.1.3.1-2: STEPS IN COMPLAINT RECEIVING IN EMERGENCY CASE

(1) Pre-construction period

(a) Positive Impacts (Community Relations Activities)

As the Project has recognized the importance of public participation in the long-term project development, community relations program has been created for the implementation during the preparation of the environmental impact assessment report to get to know the community and establish a good relationship from the beginning. The emphasis is on the consistency of activities that can reach people in the areas with close relationships, such as community activity support at the district/sub-district/village levels, etc. (Details are as shown in **Chapter 9** Public Participation and Relation Action Plan).

Apart from that, the project has also set up the Action Plan on Quality of Life Development for communities surrounding the power plant, including career development and supports of education, religion, culture, sports and music as well as public health and the environment, etc., which is a part of the policy according to the project's community relations program since the pre-construction period (Details are as shown in **Chapter 9** Public Participation and Relation Action Plan). The project shows its responsibility to society for they have recognized the importance of being a part of society that should be complementary to each other with generosity by enhancing/supporting and assisting in community activities on an ongoing basis.

- (b) Negative Impacts
 - Psychological Impact
 - Concerns

The survey results show that mostly the perception of the project information is restricted to among community leaders. Nearly all of the community heads have been informed about the project before: 90.6 % of the leaders from the area within 0 to 3 km radius of the Project site (of 32 samples, 27 community heads from sub-district administrative organization accounted for 88.9 % and 5 community heads from the local municipality accounted for 100.0 %) and 95.0 % of the leaders from the area within 3 to 5 km radius of the Project site (of 20 samples of community heads from sub-district administrative organization accounted for 100.0 %). On the contrary, the majority of household population has just been informed about the Project for the first time: 48.6 % of the households from the area within 0 to 3 km radius of the Project site (of 428 samples, 308 households from sub-district administrative organization accounted for 3 km radius of the Project site (of 428 samples, 308 households from sub-district administrative organization accounted for 3 km radius of the Project site (of 428 samples, 308 households from sub-district administrative organization accounted for 60.4 % and

120 households from the local municipality accounted for 18.3 %) and 68.8 % of the households from the area within 3 to 5 km radius of the Project site (of 93 samples of households from sub-district administrative organization). During the interview, the staff explained briefly about the Project again to ensure a clear understanding. After such explanation, although the proportion of the community leaders with the perception of the Project is clearly higher when compared with the households from the areas of less than 3 km and within 3 to 5 km radius of the Project site, the interview results show that that concerns on project development of all four sample groups is consistent: the level of concerns is relatively low. This is due to the fact that the Project area is located in the industrial estate and at present, most people have a better understanding about natural gas from several media publicized by related agencies, following the government policy to promote the use of NGV over the past years. It can be concluded that the Project location and the use of natural gas fuel for electricity generation are variables that have direct impact and are significant to the concerns of the communities even though they perceived the information for the first time. Details are as follows:

The Population With Concerns: 6.3 % of the leaders from the area within 0 to 3 km radius of the Project site (of 32 samples, 27 community heads from sub-district administrative organization accounted for 3.7 % and 5 community heads from the local municipality accounted for 20.0 %); 35.0 % of the leaders from the area within 3 to 5 km radius of the Project site (of 20 samples of community heads from subdistrict administrative organization); 14.3 % of the households from the area within 0 to 3 km radius of the Project site (of 428 samples, 308 households from subdistrict administrative organization accounted for 12.3 % and 120 households from the local municipality accounted for 19.2 %); 16.1 % of the households from the area within 3 to 5 km radius of the Project site (of 93 samples of households from sub-district administrative organization, concerns observed from all four population groups are consistent with the same trend: mostly concerns about the operation of the power plant. For example, air pollutants, discharged water quality, fight over water, traffic during the construction period, security of life and property, impacts on the community environment, and failure to follow the established measured strictly, etc. (see Figure 5.1.3.1-3).



FIGURE 5.1.3.1-3: CURRENTLY CONCERN ABOUT PROJECT DEVELOPMENT

The Population With No Concerns: 90.6 % of the leaders from the area within 0 to 3 km radius of the Project site (of 32 samples, 27 community heads from sub-district administrative organization accounted for 96.3 % and 5 community heads from the local municipality accounted for 60.0 %); 65.0 % of the leaders from the area within 3 to 5 km radius of the Project site (of 20 samples of community heads from sub-district administrative organization); 85.0 % of the households from the area within 0 to 3 km radius of the Project site (of 428 samples, 308 households from sub-district administrative organization accounted for 87.0 % and 120 households from the local municipality accounted for 80.0 %); 83.9 % of the households from the area within 3 to 5 km radius of the Project site (of 93 samples of households from sub-district administrative organization). It can be clearly seen that *the interview results of all four sample groups are consistent: the proportion of no concerns is relatively high* (Figure 5.1.3.1-3). This is due to the fact that the Project area is located in the industrial estate and at present most people have a better understanding about natural gas.

The Population With No Comments (Not Specify): The interview results show that some people have no comments because they either have no knowledge or insufficient information about the project. This group represents the least

when compared with the rest of the samples: 3.1 % of the leaders from the area within 0 to 3 km radius of the Project site (of 32 samples, 27 community heads from sub-district administrative organization accounted for 0.0 % and 5 community heads from the local municipality accounted for 20.0 %); and 0.7 % of the households from the area within 0 to 3 km radius of the Project site (of 428 samples, 308 households from sub-district administrative organization accounted for 0.6 % and 120 households from the local municipality accounted for 0.8 %). (See Figure 5.1.3.1-3)

However, the community concerns have significant impact on the Project development. Modern communication technology that allows the swift and diverse transfer of information, especially the negative pieces of news about power plant projects in different areas that have happened before, causes different levels of concerns depending on basic knowledge and understanding of the people in each location. *Therefore, in order to disseminate project information to cover wider areas and reach more people, the Project implements a public relations program focusing on enhancing knowledge and understanding about the operation of the power plant. Such activities are conducted at district/sub-district/village levels, at the time of preparing the environmental impact assessment report (details are as shown in Chapter 7 Information disclosure, public consultations and participations).*

Moreover, the project has also established the Action Plan on Public Participation to promote clear and accurate knowledge and understanding about the Project consistently and continually at the pre-construction period, construction period and during the operation period (details are as shown in Chapter 9 Public Participation and Relation Action Plan). The power plant visit, in particular, is arranged to welcome to the community leaders and the people who are interested in receiving accurate information about the project. In this activity, the visiting people are given opportunity to experience the actual working environment at the real places. This will help raise the awareness in the Project nature as well as increase the confidence in the operation of the project. In addition, an in-person discussion with the staff can also build the relationships and reduce the gap between the community and the project. *The impacts are then estimated to be low.*

Creditability

Due to the fact that the perception of news and information about the power plants of the same type in other areas can be taken as the lesson learned for the community, particularly concerning the obligation to follow the pollution preventive and mitigation measures and the lack of the remedial measures for the communities from the relevant agencies, some people in the area have relatively negative feelings against the existence of the project, in terms of the reliability of the Project operation and hesitation in the creditability of the organization (Gulf SRC Co., Ltd.) who is responsible for the Project development in this area for the first time and hence not yet well known to the community.

The organization creditability and the Project reliability that the communities have are the impacts that have high level of significance on the Project development, particularly the organization's responsibility and management concerning the communities both in normal conditions and problem incidents/impacts on the communities during the project development. Therefore, key variables being the creditability of the project/organization and setting up plans and assigning the responsible persons to directly coordinate with communities to bridge the communication gap between the community and the project, as well as showing the project's sincerity and transparency in all procedures through various forms of activities according to the action plan on public participation continually will *maintain impacts at low level*. In addition, this will also strengthen the work performance and confidence, create an excellent image of the organization, as well as maintain good and sustainable relationships and friendships between the communities and the project.

- (2) Construction Period
 - (a) Positive Impacts
 - (a1) Social Impacts
 - Community Economy
 - Increase employment opportunities for local workers

The employment benefits are low. Although the number of workers during the construction period can be up to approximately 3,200 persons, employment in the construction period is the responsibility of the contractor. Therefore, employment benefits that the local people will get depend solely on the contractor's
management which in practice often hires those from their existing pool of workers who already have contracts.

However, according to the specified preventive and mitigation measures, the project will request that the contractor consider hiring local people first to reduce the potential impacts that migrant workers may cause as well as to increase benefits to the local communities.

Moreover, the future operation plans of the power plant project, which is categorized as a large project in the area, are considered as a great motivation to the local youth to have higher education ambition. In addition, this may also urge local residents to send their children to school until higher education level in order to seek employment in the power plant in their own homeland.

- Promote the local economy

The benefits to the economy in the areas are from general spending made by the construction workers, increasing more cash flow. It is estimated that there can be up to about 3,200 workers and employees during the construction period. Their spending on a daily basis will help promote the income of the community, especially the restaurants and retailers. Considering the minimum wage rate of Chon Buri Province of 300 baht/day/person and the same rate for Rayong Province (The Wages Board's Notification re: Minimum Wage Rates (Volume 7), dated 10 October 2012) with the working day of about 25 days/month, it can be estimated that cash flow during such period can be up to 24,000,000 baht/month or 288,000,000 baht/yr, making the total cash flow during the construction period (51 months) of 1,224,000,000 baht. This of course is a positive impact to the community and local economic system (estimated from 88.2 % of the consumption expenditure, source: National Statistical Office, *Summary of Preliminary Results of the State of Household Socio-Economic Survey, the First Six Months of the Year 2013,* http://service.nso.go.th/nso/nsopublish/themes/files/socioSum5 6 - 6 . pdf, retrieved on 9 March 2015.).

• Occupation

In the construction period, the Project will employ up to 3,200 workers. This will result in an increase in the spending within the areas surrounding the project. Since there will be many more people coming into the area, shops around the Project site will sell more. In addition, the contractor's purchases and some basic operations will also

contribute to the revenues of the shops or construction equipment, machinery and hardware stores and transport services. This will result in an increase in the province's gross domestic product, and eventually the per capita income of the people in the areas will also increase.

• Power Development Fund benefits to the community

During the construction period (since the start of the power plant construction under the agreement with construction contractor until the commercial operation date (COD)) it is required that annual payment according to the installed electricity generating capacity of the power plant in the rate of 50,000 baht/MW/yr shall be made to the fund. In this regard, with the installed electricity generating capacity of 2,650 MW, 132,500,000 million baht/yr will be paid to the Power Development Fund (in accordance with the Energy Regulatory Commission's Notification re: Contributions to the Power Development Fund for the Electricity Industry Licensees, B.E. 2553) throughout the construction period of approximately 51 months.

(a.2) Community Relations Activities

Measures to create a better understanding include channels for complaints and opportunities for public participation in the implementation of preventive and mitigation measures in order to demonstrate transparency and authentic monitoring in the form of a committee to monitor the environmental impact of the project. This includes *community development activities that the power plant has continued to financially support and contribute to the people's better quality of life in accordance with the social action plan to the communities surrounding the Project area which gives a positive impact.*

In addition, the Project has also established public policy under the strategies of "proactive corporate social responsibility on a consistent and continual basis". This is done by appropriately providing support and assistance to community activities to build good relationships and give benefits in return to communities and society (details are as shown in **Chapter 9** Public Relations and Public Participation Action Plan).

(b) Negative Impacts

(b.1) Psychological Impacts

Based on the interviews about the potential impacts on the communities during the construction period, *it is found that the majority of the respondents replied that they believe to have no impacts*. However, some are still worried and expect to be affected by the construction. This groups include the 12.5 % and 20.0 % of the community leaders from the area within 0 to 3 and 3 to 5 km radius of the Project site respectively and 10.3 % and 7.5 % of households from the area within 0 to 3 and 3 to 5 km radius of the Project site respectively and 10.3 % and 7.5 % of households from the area within 0 to 3 and 3 to 5 km radius of the Project site respectively (Figure 5.1.3.1-4). The expected impacts include particulate emissions from the construction, traffic accidents, water conflicts, and community safety, etc.

In this regard, measures to create a better understanding include channels for complaints and opportunities for public participation in the implementation of preventive and mitigation measures in order to demonstrate transparency and true monitoring in the form of a committee to monitor the environmental impact of the project. This can enhance mutual understanding on the Project operation by the communities *leading to a low degree of impacts*.



FIGURE 5.1.3.1-4: THE POTENTIAL IMPACTS ON THE COMMUNITIES DURING THE CONSTRUCTION PERIOD

(b.2) Physical Impacts

• Air quality

The assessment of air quality estimated during the construction period in the scenario with water spraying measure shows that 24 hr average TSP increases to 95.23 μ g/m³. This amount when combined with the quantity of particulates from the measurement of 153 μ g/m³, the total 24 hr average TSP is 248.23 μ g/m³ or 75.22 %. When comparing the total 24 hr average TSP with the ambient air quality standard that specifies that TSP must not exceed 330 μ g/m³, it can be concluded that the measured TSP is within the ambient air quality standard *and may cause impacts relating to air quality in terms of increased particulates low*.

• Noise nuisance

The assessment of noise impacts estimated in the sound sensitive area during the construction shows that the noise nuisance level of the Project construction is higher than the prescribed standard. However, the Project has established the mitigation measures in the construction period, i.e. contractors are required to use machinery that generates low noise. In addition, the Project has also implemented additional mitigation measures with the installation of the temporary noise barriers around the piling areas in the northeast and the south of the Project site, made from steel sheet of 1.27 mm thickness (steel, 18 ga) or more, yielding the transmission loss of 25 dB(A) with the heights of the barriers in the northeast and the south of 3 m and 5 m respectively. Therefore, after the installation of the temporary noise barriers, the noise nuisance at the sensitive areas has decreased to be under the prescribed standard. As a result, it is estimated that *the noise nuisance level of the Project construction will temporarily impact the people living near the Project site low.*

• Water usage

During the Project construction, the expected maximum number of workers are 3,200 persons, all of which will stay outside the Project site. Their demand for water usage is about 224 m³/day (estimated from the rate of water use by construction workers of 70 L/person/day. The water for consumption is sufficiently provided by the contractor (may be supplied by Hemaraj ESIE's water supply system) while drinking water is the purchased bottled water. Therefore, the water usage during the Project construction is estimated not to cause any impacts on the community's water use. As a result, *the* Project's use of water does not cause any water usage impact on the people living nearby.

Solid waste management

Solid wastes that may be produced during the construction period include garbage from worker community and garbage from temporary office. During the period with the maximum of 3,200 workers, it is projected that 2,720 kg of garbage will be produced per day (estimated from the garbage generation rate of 0.85 kg/person/day). The project has established specific areas to collect and store such garbage separately using suitable containers. Recyclable garbage will be reused or sold to waste buyers and the rest will be transported for further management by local authorities. The hazardous wastes will be collected and further disposed by the company authorized by the Department of Industrial Works using a proper technical basis. As a result, *the impacts related to waste/garbage is low*.

(b.3) Social Impacts

• During the construction period, people in the communities might still have some opinion conflicts regarding concerns about the project. This may be due to the fact that some people do not have accurate understanding about the Project operation details and its potential impacts. Therefore, the Project plans to have ongoing power plant visits to enhance knowledge and understanding about electricity generation process to people all across the villages in the radius of 5 km from the Project site and provide channels for complaints and engaging people in the implementation of preventive and mitigation measures in order to demonstrate transparency and authentic monitoring in the form of an environmental impacts monitoring committee. As a result, the Project will have *low impact on social aspect*.

• Socio-cultural conflicts among migrant workers and local people and among workers themselves may cause several subsequent problems, including migration or demographic shifts, quarrels, vices/immorality, petty theft, drug abuse, and cultural conflicts that may arise from the differences in living and way of life concerning a changing lifestyle. However, setting up the policy and guideline for hiring local people as a priority according to the measures in the Socio-Economic Action Plan will result in *a low level of socio-cultural impacts*. • Regarding the health and safety of the people living around the Project site, the project construction activities might cause physical environmental impacts in the project area and surrounding areas, which will consequently affect the health of the local people in the communities. In addition, the migration of the workers into such communities might also cause some problems regarding the safety and security of the community's property. Therefore, the project has established measures to strictly control the behaviors of the workers. As a result, *the impact related to health and safety is low*.

- (3) Operation Period
 - (a) Positive Impacts
 - (a.1) Social Impacts

• The revenues of Khao Khan Song Sub-district Administration Organization (SAO), the location of the project, will increase from the collection of property tax. The amount of money is depending upon the rate set by each SAO/municipality. In addition, the development as a result of an existence of a power plant in the area will allow the SAO/municipality to collect more of other taxes including land tax, household tax, vehicle and transportation-related taxes, and signboard tax, etc. Therefore, the budget for local development will be more.

• Regarding the return of community benefits during the electricity generation phase starting from the commercial operation date (COD), the Project will send the contribution to the Power Development Fund due to the use of natural gas as fuel. The contribution rate is 1 satang/electricity unit generated for commercial purposes each month. This excludes the cost of electric power used in production process within the power plant throughout the Project's operation period (about 25 yr).

• The project development is considered the country's increase in the amount of electric electricity generation to provide the public with sufficient electricity. This also supports other manufacturing sectors, particularly industrial sector, because electricity is the main factor for the growth in the industrial sector. Therefore, this will result in higher employment, the increased gross domestic product of the province as well as the country's GDP.

• The development of people in the community to have a better knowledge and understanding about the Project development is conducted through various activities, such as vocational training, offering grants and scholarships to students, etc. These are ongoing activities implemented in continuation of the operation of the power plant in order to develop the people's potential to pursue better knowledge and understanding for further community development.

(a.2) Community Relations Activities

Community relations activities are arranged by the owner of the project, Gulf SRC Co., Ltd. The main purpose is to promote a better and mutual understanding with the community, emphasizing on the consistency and the access to reach people in the area to build a close relationship. Supports for various community activities are also provided at district/sub-district/village levels, covering vocational development, supports in education, religion, tradition, culture, sports and music, as well as public health and environment. In addition, the Project also arranges community relations activities in the form of two-way communication to exchange ideas and suggestions between each other. Such activities include the power plant visit with the objectives to: create a learning process based on direct experience of the target population; build mutual understanding and reduce the concerns about the Project operation; and contribute to a better coexistence between the communities and the project.

The implementation of the plan to boost up the community understanding is laid out to be further integrated with the action plan on the people's participation and public relations. It is expected that these activities will encourage more public sector engagement as well as enhance and optimize the operations of the Project's Environmental Impact Monitoring Committee to improve its performance in obtaining an access to the root cause of any problems according to the mechanism of complaint procedures so that the operation can be consistent with public opinions. Eventually, this will allow the development of the power plant project to be as smooth as possible, leading to a peaceful coexistence with the community in a sustainable manner.

Furthermore, in order to achieve the sustainable activities according to the community development plan, the implementation of the activities/projects is based on the understanding and awareness that valuable community development shall begin from within the community itself where people play a role in sharing their ideas and working together to achieve sustainable development in various aspects within their own community which they all share responsibility. In this regard, such activities/projects may include the Quality of Life Improvement Project to change and/or improve the people's quality of life in terms of basic social service facilities, public utilities, natural resources and environment, professional development and income empowerment, educational support, public health promotion and community healthcare support, etc (details are as shown in **Chapter 9** Public Relations and Public Participation Action Plan).

(b) Negative Impacts

(b.1) Psychological Impacts

The results of the interview on the potential impacts that the community might have as a result from the Project operation shows that *the majority of all sample groups perceived that there will not be any significant impact, revealing an overall picture of a slightly increased proportion when compared with the construction period*. A small proportion of the respondents found that there might be an impact on the community: 12.5 and 30.0 % of the community leaders from the areas within 0 to 3 and 3 to 5 km radius of the Project site respectively; and, 11.2 and 9.7 % of the households from the areas within 0 to 3 and 3 to 5 km radius of the Project site respectively (Figure 5.1.3.1-5). However, the community leaders from the areas within 3 to 5 km radius of the Project site shows relatively high level of concerns (35 %). Seven community heads have some concerns about the development of the project, including 3 from Khao Khansong Sub-district, 3 from Khlong Kio Sub-district, and 1 from Nong Suea Chang Sub-district. Their concerns include:

- Prevention of environmental pollution;
- Traffic volume in the areas;
- Drainage of wastewater from the project;
- Environmental impacts;
- Standard of monitoring measures of the Project in the future;



- Lack of confidence in the work system.

FIGURE 5.1.3.1-5 : THE POTENTIAL IMPACTS ON THE COMMUNITIES DURING THE OPERATION PERIOD

According to the above, the cause of the concerns of the community leaders is analyzed. The consultant found that the areas under the supervision of these community heads already have existing problems being the operation of some establishments causing a negative impact on the communities nearby. For example, a poultry farm in Khlong Kio Sub-district causes the impact related to odor and wastewater on the community. Khao Khansong Sub-district has the environmental impacts resulting from the companies in the industrial estate nearby, particularly the air pollution and wastewater. Similarly, Nong Suea Chang Sub-district has received complaints from the local residents about the illegal transportation of solid waste from the plants to dump in the area. Therefore, the existence of this project in the area will cause additional concerns, especially about the impacts that may result from the Project operation in the future. Although the Project is not located in their areas, the current concerns about the Project development are still considerably high. Their stated concerns are mainly about the environmental impacts estimated to arise from the Project development, including the accumulated impacts that may take place as a result of the long-term operation of the power plant.

In this regard, the Project has established the plan to improve the community understanding, which is laid out to be further integrated with the action plan on the public participation and public relations. It is expected that these activities will encourage more public sector engagement as well as enhance and optimize the operation of the Project's Environmental Impact Monitoring Committee to improve its performance in obtaining an access to the actual cause of any problems to be in accordance with the mechanism of complaint procedures so that such operation can be consistent with public opinions. In addition, the measure to enhance the community with a better knowledge is also provided though the power plant visit with the objective to create a learning process based on direct experience in the actual power plant area. Local people who are interested in the operation of the power plants and have environmental concerns will be invited to visit power plant. Eventually these activities will allow the community to strengthen constructive understanding about the Project operation, **leading to a low degree of psychological impact.**

(b.2) Physical Impacts

• Air quality

The assessment of air quality impact by modeling using AERMOD in the studied areas in general and in the sensitive receptor is based on the estimation of ambient air quality in scenario 3 the impact of the Project (with the scenario of natural gas fuel running at 100 % load), including the current impact of air pollutants from other industrial factories that have been approved in the environmental impact assessment report but have not yet been releasing air pollutants as well as from the power plants in the plan proposed by Gulf Group within a radius of 15 km from the Project site. The combination of the estimation and the currently measured values shows that the maximum concentration of air pollutants is within the standards: the 1 hr average concentration of NO₂, the 1 hr and 24 hr average concentration of SO₂, and the 24 hr average concentration of TSP and PM-10 account for 90.60, 24.52, 22.88, 56.45 and 97.85 % of the ambient air quality standard.

The air quality impacts resulting from the power plant operation as a whole shows lower concentration than the ambient air quality standard. Moreover, the Project is also committed to monitor the air quality by measuring the amount of NO₂, SO₂, TSP and PM-10 emissions from the vent continually and to contain them within the levels of the prescribed standards. These measures are implemented in order to prevent potential adverse effects on public health and agricultural products in the vicinity of the Project area as well as to be strictly compliance with the preventive and mitigation measures for the impacts from the operation of the project. Therefore, *the air quality impacts are low.*

• Noise Nuisance

According to the impact assessment of sound level and noise nuisance level produced by machinery and equipment during the operation period, the sensitive areas which are the representatives of the sound sensitive area surrounding the Project had noise nuisance level during the operation period lower than the prescribed sound pressure level standard (noise level of not exceeding 10 dB(A)). In this regard, the noise resulting from the activities of the Project operation will be confined within the Project area only. Moreover, the Project has established mitigation measures to limit the potential noise impacts on the surrounding communities. For example, the machines that produce loud noise will be installed with a noise reduction equipment such as a silencer at the end of the pipe, which may cause a loud noise. Furthermore, a building will be constructed to cover the machine in the combustion chamber of a gas turbine, at the gas turbine generator. The Project is also committed to monitor the noise impacts on a continuous basis throughout the Project's operation period. As a result, *the noise impacts are low.*

Water pollution/aquatic ecology

Discharged water from the Project can be divided into two categories as follows:

1) Cooling blowdown of about 12,232 m³/day will be transferred to the cooling water holding pond. There are 2 ponds: each has a capacity of 19,000 m³. While one pond is being used, the other will be assigned as the emergency pond. This is done prior to the drainage into Hemaraj ESIE's cooling water holding pond which can hold the cooling blowdown up to 1 day. The discharged cooling blowdown must have the temperature in accordance with the standard specified by Hemaraj ESIE. In this regard, the cooling blowdown holding pond is installed with the online monitoring equipment to measure the temperature, pH, DO, and conductivity of the cooling blowdown to be discharged according to such standard.

2) Wastewater from the process of about 48 m³/day includes:

> Discharged water from water treatment systems, demineralization and mixed bed regeneration, of about 13 m³/day will be drained into the neutralization pond to neutralize the pH before discharging into the Project's wastewater holding pond;

> Discharged water from the laboratory of about 5 m³/day will be drained into the neutralization pond to recondition the pH before discharging into the Project's wastewater holding pond;

Wastewater from the consumption of about 30 m³/day will be treated in the septic tank before discharging into the Project's wastewater holding pond. All the discharged water from production activities in 2) will be stored in the wastewater holding pond. There are 2 ponds with the capacity of 75 m³ each (the total capacity of up to 3-day storage). These ponds are installed with the online monitoring equipment to measure the temperature, pH, and conductivity of the wastewater in the pond. The measured values must be in compliance with the standards

specified by Hemaraj ESIE prior to further discharge into the central wastewater treatment system.

The bed of the holding ponds will be designed to prevent the leakage of wastewater into the ground, for example using pond lining. In addition, a frequent monitor and maintenance of the pond must be conducted on a regular basis, including a timely repair if damaged.

Regarding storm water drainage system, uncontaminated rainwater will be collected and further discharged through the Project's storm water drainage system. It is apparent that the entire wastewater from production process must be treated by the Project's wastewater treatment system and its quality is controlled according to the wastewater standard specified by Hemaraj ESIE as well as strictly following the environmental impact preventive and mitigation measures proposed in the environmental impact assessment report. As a result, *the impacts related to water pollution are low*.

• Solid waste management

➤ General garbage: The garbage from office building of about 51 kg/day (estimated from the maximum of 60 employees and the average quantity of garbage generated of 0.85 kg/person/day, ref. Kriengsak Udomsinroj, 1994), including leftover food, plastic bags, etc., will be collected and handled/transported for further disposal by either Hemaraj ESIE authorized agencies or the local authorities.

Spent air filters: The air filters prevent airborne dust and debris from getting through to the electric electricity generation system of the power plant. As the filter is made from polyamide fiber, it cannot be reused because the dust particles attached to the fiber of the filters are very dense and moist that they cannot be blown or washed out. Therefore, when being used for a certain period of time, the air filters need to be replaced. The quantity of used air filters is estimated to be 4,704 pieces/1.5 yr. The used air filters will be transported for disposal by the industrial waste management company authorized by the Department of Industrial Works.

> Used lubricating oil and oil from oil/water separators: the quantity of used lubricating oil and oil from oil/water separator is estimated to be 800 L/month which will be collected in 200-L steel drums and transported for further disposal by the industrial waste management company authorized by the Department of Industrial Works.

➤ Used resins: Each year, the quantity of used resins that need replacement are estimated to be approximately 1 m³/yr. This amount will be returned to the manufacturer or separately collected in plastic bags to be kept in the 200-L oil drums and subsequently transported for disposal by the industrial waste management company authorized by the Department of Industrial Works.

Sludge from pre-water treatment system: The pre-water treatment system separates sediments from raw water. The quantity of sediments resulting from this water treatment is about 5 tons/day and will be collected in the sludge hoppers and stored inside the initial water treatment building and subsequently transported for disposal three time per week. The disposal will be in accordance with Ministry of Industry's Notification B.E. 2548 re: Disposal of Garbage or Discarded Materials, or by the industrial waste management company authorized by the Department of Industrial Works.

According to the garbage and solid waste management measures mentioned above, it can be concluded that *the impacts related to garbage and waste are low*.

(b.3) Social Impacts (Public Health and Safety)

During the operation period, it is estimated that the maximum number of 60 employees will be required. However, the Project has established the policy to hire local workforce as the first priority. Other measures include the strict supervision of the behavior of the staff/employees, the reduction of the risk of contagious disease problems, and the environmental sanitation. Moreover, the engagement of public participation in the implementation of environmental impact preventive and mitigation measures is also implemented to boost public confidence in the Project operation in order to demonstrate transparency and authentic surveillance in the form of Environmental Impact Monitoring Committee. Therefore, it can be concluded that *the social impacts related to public health and safety are low*. Mitigation measures

(a) Pre-construction Period

General Measures

• Establish good relationship with officers of the local government and people in the communities.

• Participate in awareness of Sriracha Power Plant Project by means of dissemination of the project's information through the media or any of the following: local radio broadcasting, installation of notice boards displaying construction plan at key points in the area, such as, at the offices of the community leaders, at the sub-district administrative office organization office and by other methods consistent with the objectives of such measures, etc. one month prior to the construction.

• Support the activities within the community wherever appropriate in order to establish good relationship as a mean of returning benefits to the community and the society.

• Publicize and clarify facts to the public urgently, in case of misunderstanding between the power plant, and the community through various channels or media so people receive factual information. Be prepared to demonstrate that the project will take responsibility and care about people's feeling.

Measures on Public Relations

1. Objective of Public Relations

The project aims to give news and information about the project continuously to people in the vicinity from the pre-construction period, the construction period and the operation period, act as a channel of communication between the local communities, listen to the opinions of the people in the vicinity who may be affected by the operation of the project, and give people the opportunities to express their opinions and suggestions to the project.

2. Channel of Public Relations: at least one of the following channels of information dissemination of the project or activities relevant to such objectives, such as:

• By means of Local Media such as through the cable broadcasting in the community or local cable media, as appropriate.

• By means of Notice Boards or PR boards of relation local government agencies, in the communities or visible public places, for examples, PR boards of the district officer involved in the project, PR boards of the municipality or the sub-district administrative office organization office involved in the project, PR boards of the public health agencies in the study area and at the project site.

• By means of placement of project's public relation documents and brochure to publicize details of the project and progress of the project (during each phase of the operation), safety information and prevention of emergencies, channel of communication in case of emergencies and channels of complaints on the operation of the project, channel of communication of the project, at the point of public relation of government agencies, the communities and at the points accessible by the people.

•

By means of meeting to explain about the project as

follow:

- Hold a meeting to report details/progress through local government agencies in the area (provincial level and district level) at least once prior to the construction or within the first month of the construction.

- Hold a meeting to report details/progress of the project to the villages/communities/ related sub-districts, at least once prior to the construction or within the first month of the construction.

• By means of the Community Participation for Committee throughout the term of the Community Participation for Committee.

• By means of distribution of stickers with channel of contacts with the project to the communities in the vicinity as a channel of contact in case of emergency or desires to report information on the impacts from the operation of the project.

• By other means as appropriate, such as, door-to-door campaign, mobile broadcasting, etc.

The public relations activities must consist of details of the project, progress, construction duration, impacts from the project development, environmental impact prevention and mitigation measures, channel of contacts and communication with the project, channel for complaints on project operation and channel of contacts in case of emergency.

- (b) Construction Period
 - Environmental impact prevention and mitigation measures

• Establish a "Complaint Receiving Center" in order to publicize the project and to listen to opinions, suggestions and complaints. Those affected by the project can complain about the impacts or the problems through the channels in any manners or as deem appropriate, e.g. verbal complaints, telephone, memorandum, letter, Email, fax, etc. as shown in **Figure 5.1.3.1-6** and in case of emergency as in **Figure 5.1.3.1-7**

• Comply with the environmental impact prevention and mitigation measures strictly.

• Receive complaints regarding matters troubling people in the communities affected by the construction activities and take corrective action on such impacts urgently.

Measures Regarding Safety of Life and Property

- Give priority of hiring qualified local residents.
- Keep records of non-local and foreign workers.
- Assign the head of the project to supervise workers. Assign employees to monitor entry into and exit from the project strictly.

• Control the construction activities and the workers' behaviors to prevent impacts to people in the vicinity.

• Set up zoning for workers' temporary living quarters and construction area.

• Issue work regulation and ensure that construction worker strictly

comply with the regulations.

• Monitor and control workers' behaviors closely if their living quarters are near local communities so as not to disturb the nearby communities.



*Note: "Reporting progress in resolving the problems to the complaining party every 7 days or as agreed. Figure 5.1.3.1-6 : Scheme of Operation on Sriracha Power Plant Project's

Complaint Receiving



Figure 5.1.3.1-7 : Steps in Complaint Receiving in Emergency Cases

• Publicize and clarify facts to the public urgently, in case of misunderstanding between the power plant, and the community through various channels or media so people receive factual information. Be prepared to demonstrate that the project will take responsibility and care about people's feeling.

• Take corrective action urgently where it is proved that the power plant is the cause of such impacts. Set up a register of individuals or groups being affected and use the data to implement stricter measures to prevent the problems.

• Prepare a register of people affected, recording issues from the complaints or from the event as evidence. Record information related to proof of facts, solutions, negotiations, and arrangements as evidence of the power plant operation.

Measures in Public Relations

1. Objectives of the Public Relations

• To give news and information about the project continuously to people in the vicinity from the pre-construction phase, the construction phase and the operation phase

• To act as a channel of communication between the local communities, listen to the opinions of the people in the vicinity who may be affected by the operation of the project, and give people the opportunities to express their opinions and suggestions to the project.

2. Channel of Public Relations: at least one of the following channels of information dissemination of the project, or activities relevant to such objectives, such as:

• By means of Local Media such as through the cable broadcasting in the community or local cable media, as appropriate.

• By means of Notice Boards or PR boards of relation local government agencies, in the communities or visible public places, for examples, PR boards of the district officer involved in the project, PR boards of the municipality or the sub-district administrative office organization office involved in the project, PR boards of the public health agencies in the study area and at the project site.

• By means of placement of project's public relation documents and brochure to publicize details of the project and progress of the project (during each phase of the operation), safety information and prevention of emergencies, channel of communication in case of emergencies and channels of complaints on the operation of the project, channel of communication of the project, at the point of public relation of government agencies, the communities and at the points accessible by the people.

• By means of distribution of stickers with channel of contacts with the project to the communities in the vicinity as a channel of contact in case of emergency or desires to report information on the impacts from the operation of the project.

• By other means as appropriate, such as, door-to-door campaign, mobile broadcasting, etc.

The public relations activities must consist of details of the project, progress, construction duration, impacts from the project development, environmental impact prevention and mitigation measures, channel of contacts and communication with the project, channel for complaints on project operation and channel of contacts in case of emergency.

(c) Operation Period

General Measures

• Establish measures for hiring qualified local people first to reduce impacts on the relationship with the people in the communities. Publicizing vacancies in the communities when job vacancies are available.

• Establish measures to return benefits to the communities, such as, supports for local education, local public health, religion promotion and supports for other public benefits.

• Assign a person in charge of receiving complaints, and listen to opinion and suggestions. Affected persons may make a complaint on the characteristic of the impacts or the problems through various channels to the power plant, such as, verbal complaints, telephone, memorandum, letter, emails, fax, etc. as in **Figure 5.1.3.1-6**.

• Organize a power plant visit for communities to reduce their

• Establish a policy for life quality promotion. Support and promote community business for sustainable socio-economic development of the communities.

concerns.

• Follow the steps specified in the action plans strictly to reduce accidents and impacts to the project and to the communities.

• Take corrective action urgently where it is proved that the power plant is the cause of such impacts. Set up a register of individuals or groups being affected and use the data to implement stricter measures to prevent the problems.

• Prepare a register of people affected, recording issues from the complaints or from the event as evidence. Record information related to proof of facts, solutions, negotiations, and arrangements as evidence of the power plant operation.

• Publicize and clarify facts to the public urgently, in case of misunderstanding between the power plant, and the community through various channels or media so people receive factual information. Be prepared to demonstrate that the project will take responsibility and care about people's feeling.

Measures in Public Relations

1. Objectives of the Public Relations

• To give news and information about the project continuously to people in the vicinity from the pre-construction period, the construction period and the operation period.

• To act as a channel of communication between the local communities, listen to the opinions of the people in the vicinity who may be affected by the operation of the project, and give people the opportunities to express their opinions and suggestions to the project.

2. Channel of Public Relations: at least one of the following channels of information dissemination of the project, or activities relevant to such objectives, such as:

• By means of Local Media such as through the cable broadcasting in the community or local cable media, as appropriate.

• By means of Notice Boards or PR boards of relation local government agencies, in the communities or visible public places, for examples, PR boards of the district officer involved in the project, PR boards of the municipality or the Sub-district Administrative Office organization office involved in the project, PR boards of the communities involved in the project, or PR boards of the public health agencies in the study area and at the project site. • By means of placement of project's public relation documents and brochure to publicize details of the project and progress of the project (during each phase of the operation), safety information and prevention of emergencies, channel of communication in case of emergencies and channels of complaints on the operation of the project, channel of communication of the project, at the point of public relation of government agencies, the communities and at the points accessible by the people.

• By means of distribution of stickers with channel of contacts with the project to the communities in the vicinity as a channel of contact in case of emergency or desires to report information on the impacts from the operation of the project.

• By other means as appropriate, such as, door-to-door campaign, mobile broadcasting, etc.

The public relations activities must consist of details of the project, progress, construction duration, impacts from the project development, environmental impact prevention and mitigation measures, channel of contacts and communication with the project, channel for complaints on project operation and channel of contacts in case of emergency.

5.1.3.2 Health impact assessment

Construction Period

Construction activities posed threats to health of workers and people in sensitive receptors within a 5 km radius from the project area's boundary. Health impact was caused by project activities' threats such as particulate matter and noise from construction activities, accidents from traffic, transportation, work performance, stress, anxiety and concerns on impact or project activities. Results from health impact assessment during the construction period are as follows:

(1) Air quality (Particulates Matter)

Air pollution was the major risk during the construction period of the project. The pollution included total suspended particulates (TSP) that originate mainly from construction activities such as foundation laying, building setting and transportation of materials, equipment, tools used in construction and construction scrap. Details are as follows:

(a) Characteristics of health impact from particles includes symptoms of eye irritation and symptoms of respiratory irritation when inhaling air containing particles. Irritation symptom occurs on different parts of respiratory system. Large particles will be captured by nostril hair while small particles will pass into the respiratory system, causing irritation, burning sensation, coughing, sneezing, having phlegm or developing the accumulation of particles in lungs that will deteriorate lung functions. In addition, dust particles can reduce visibility and cause dirtiness and disturbance. From a study by Chulalongkorn University, it was found that students who lived in areas where the quantity of particles smaller than 10 microns (PM-10) exceeded 100 µg/m³ had higher rate of respiratory system diseases than children who lived in the areas where the quantity of PM-10 was under 50 µg/m³. Also, the study found that the severity of symptoms changed in proportionate with the changing levels of concentration of particles (College of Public Health, 1995).

(b) Major activities causing health impact were the particle source during the construction period included building setting and transportation of materials, equipment, tools used in construction and construction scrap. Typically, particles from construction activities which are generated during the preparation and construction period will be temporary and last for a short period of time. It poses an important health threat - TSP - generated from construction activities and transportation of materials, equipment and tools.

(c) Risk groups that might be affected by TSP generated from open land excavation and open cut during the construction period can be categorized into 2 groups including construction workers and project's employees. They are considered primary risk groups because they are exposed to TSP all through the period of 8 hr of work (Time Weighted Average, TWA) in case they do not use personal protective equipment (PPE) or there are no mitigation and preventive measures for air quality impact. Secondary risk group consists people living within a 5 km radius from the project area's boundary which the likelihood of impact and the severity of impact depends on health conditions of those who are exposed to the impact during a certain period of time and it also depends on the duration of exposure.

(d) Likelihood of health impact and the severity to health impact1. Likelihood of health impact

Construction workers and project employees: The likelihood of impact on construction workers and project employees who work in the construction site is medium because they work in the area all through the period of at least 8 hr. Therefore, the likelihood of exposure is moderate (3 points) as evidenced by the statistic that indicates the likelihood of occurrence of health impact in case of insufficient preventive measures.

People living within a 5 km radius from the project area's boundary: According to the study on the values of concentration of TSP 24-hr average from the 1^{st} measurement during 4-11 February 2014 and the 2^{nd} measurement during 14-21 August 2014 conducted at the total of 5 stations including the stations at the project area, Child Development Center of Chomphon Chao Phraya sub-district municipality, Ban Khlong Kram School, Wat Rawoeng Rangsan and Ban Nong Kang Pla, it was found that the concentration of TSP 24-hr average was within the standard (below 330 µg/m³). And, when combined this value with predicted value of particles during the construction period, the value is 248.23 µg/m³ or equivalent to 75.22 % of the standard value.

The outpatient morbidity statistics according to Ror Ngor.504 Report from hospitals in the study area indicating the health of people in the districts during 2009-2013 show that major causes of illness of local residents were respiratory system diseases, endocrine diseases, nutrition and metabolism disease and blood circulatory diseases with the morbidity rate of 29,010, 27,110 and 24,469 per 100,000 populations respectively. The outpatient morbidity statistics according to Ror Ngor.504 Report from sub-district health promoting hospitals (public health centers) indicating the health of the people in the sub-districts in the study area during 2009-2013 show that major causes of illness of local residents were symptoms, medical signs, and abnormalities found from clinical examinations and laboratories that could not be classified into any group of disease, respiratory system diseases and blood circulatory diseases with the morbidity rate of 41,698 27,439 and 10,978 per 100,000 populations respectively.

The outpatient morbidity statistics according to Ror Ngor.505 Report of local residents during 2009-2013 show that respiratory diseases were not the major cause of illness of local residents. In fact, the major causes of illness were pregnancy complications from single childbirth (normal), endocrine diseases and nutrition and metabolism diseases with the morbidity rate of 1,940 1,237 and 1,058 per 100,000 populations respectively (**Details are as shown in section 4.4.2 Health, Chapter 4**).

From interviews regarding causes of illness of people in the current environment with public health officers in the study area, 72.2 % of public health officers stated that the current environment caused illness of local residents. According to the household survey, there were approximately 39.3 % of households with patients of respiratory system diseases (allergy and irritation in the throat/nose) in the past year.

The data from current air quality monitoring in the study area show that the vicinity of the project can still accommodate more TSP to certain extent although it must be monitored closely because people in risk groups live in the study area and some households already suffer respiratory system diseases. Therefore, it is concluded that the likelihood of occurrences of public health impact is moderate (3 points) as evidenced by the statistic that indicates the likelihood of occurrence of health impact in case of insufficient preventive measures.

2. Severity of consequences

Construction workers and Project employees

For construction workers and project employees who work during the construction period, the severity of impact is moderate (2 points) because the project's land had been filled and graded to accommodate industrial development. Therefore, impact from particles from land adjustment activities is less likely to occur. However, construction activities as well as transportation of equipment and machineries for construction might cause dispersion of particulate matter.

People living within a 5 km radius from the Project area's

boundary

Since the construction site of the Project is located in Hemaraj ESIE which is near sensitive receptors including Wat Chomphon Chao Phraya, Chumchon Borisat Namtan Tawan-aok School and The Proud Village, the sensitive receptors might be affected by activities that might generate particles such as transportation of equipment and commuting of construction workers. However, there is no land grading activity so the severity of consequences of public health impact is moderate (2 points) as there might be chances of injuries or the accumulation of risk groups which might result in absence from work and might affect communities in the areas.

(e) Assessment of the level of health riskConstruction workers and project employees

The likelihood of impact on construction workers and project employees who work during the construction period is medium because they work in the area all through the period of at least 8 hr. Therefore, the likelihood of exposure is moderate (3 points), the severity of impact is moderate (2 points) and the significance of impact is moderate (6 points) which is an acceptable level. However, it still requires mitigation and preventive measures for the impact or improvement of the existing measures.

People living within a 5 km radius from the project area's

boundary

According to the risk assessment diagram, although the construction lasts for a short period of time and affects only within the construction site and the TSP concentration is within the specified standard, there is still possibility of impact on health such as eye and skin irritation. Such is a short term impact and can disappear when affected persons are no longer exposed to TSP. Also transportation of the project might generate particles along the driving route and the sensitive receptors are close to the project. It is therefore concluded that the severity of impact is moderate (2 points). The morbidity statistics of local residents according to Ror Ngor.504 Report from hospitals and sub-district health promoting hospitals, respiratory system diseases are the major cause of illness of local residents which corresponds with public health officers' perception that the respiratory system diseases are the major cause of public health impact from the exposure to TSP is moderate (6 points). This requires sufficient monitoring measures with possible additional measures based on the impact.

(2) Noise

(a) Characteristics of health impact caused by noise which affects physical health means deterioration of hearing system, reduction of hearing capability and several side effects such as stress, headache, high blood pressure, fatigue and heart disease. Exposure to very loud noise only once might damage the hearing system for 2-3 hr with symptoms of tinnitus or temporary deafness or permanently loss of hearing. Hearing of noise louder than normal on a regular basis can result in reduction of hearing capability, hard of hearing and even loss of hearing. The study by the Pollution Control Department shows that hearing noise of 120 dB(A) or above poses a very high risk of deafness. Hearing noise of 90 dB(A) or above for over a period of 8 hr/day or hearing noise of 70 dB(A) or above all the time can pose risk of loss of hearing and reduction of hearing capability. Noise affect mental health including feeling of annoyance. Loud noise cause failure in communication, perception and interpersonal understanding. In addition, complex work that needs high concentration to completely understand the context of work will be affected if loud noise occur during the work hours. Moreover, noise have negative impact to emotion and relaxation and reduce privacy of individuals (Crocker, 1998).

(b) Major activities that cause health impacts during the construction period that are noise sources include excavation, drilling, piling, foundation setting, structure setting, building setting, interior fit out and transporting construction materials and equipment.

(c) Risk groups that may receive health impact from exposure to loud noise include construction workers who work near noisy engines or machines and people living nearby the construction site.

(d) Likelihood of health impact and severity of consequences

1. Likelihood of health impact

Construction workers and project employees: Likelihood of impact on construction workers and project employees who work during the construction period is moderate (3 points) because they work in the areas where heavy machineries are operated as part of construction activities such as land grading, piling of foundation piles and transporting materials and equipment.

Local residents in the vicinity: The noise monitoring in sensitive receptors in the study area during 6-11 February 2014 at 3 monitoring stations

including stations at the project area, Chumchon Borisat Namtan Tawan-aok School and Wat Chomphon Chao Phraya showed that the value of Leq 24-hr average was 47.7-65.6 dB(A) with the maximum value at Chumchon Borisat Namtan Tawan-aok School equivalent to 93.7 % of the noise level standard (Leq 24-hr average not to exceed 70 dB(A)) wheas L_{max} was 76.8-109.3 dB(A) with the maximum value at Chumchon Borisat Namtan Tawan-aok School equivalent to 95.0 % of the noise level standard (L_{max} at any period of time not to exceed 115 dB(A)).

Regarding noise impacts from the construction using noise level value from machineries and equipment used in the process of excavation for foundation laying and interior fit out/inspection that generate the loudest noise, the value of noise level at 15 m away from the noise source was equal to 89 dB(A). For impact on construction workers and Project employees who worked in the construction site, they received noise from construction activities equal to 89.0 dB(A). When combined with the value of 8-hr average monitored at the current construction site (61.0 dB(A), the value is equal to 89.0 dB(A) which is within the standard of Ministry of Labour and Social Welfare's Regulation re: Prescribing Standard for Administration and Management of Occupational Safety, Health and Environment for Work with Heat, Light and Noise B.E. 2549, that allows the noise level for working 8-hr average continuously not to exceed 90 dB(A).

Regarding noise impacts to communities and sensitive receptors, including Chumchon Borisat Namtan Tawan-aok School, Child Development Center of Chomphon Chao Phraya Sub-district Municipality, Chomphol Chaopraya Temple and The Proud Village, which are 441, 666, 563 and 352 m respectively from the construction site where the foundation piling were performed, the predicted 24-hr average noise level of construction activities was 51.3-56.8 dB(A). When combined this value with the maximum 24-hr average value from the monitoring (53.7-65.6 dB(A) respectively), the value is 56.2-66.0 dB(A) or equivalent to 80.3-94.3 % which is within the noise level standard of general noise not to exceed 70 dB(A).

Although the value of noise level from the assessment is within the standard, the maximum value reached 94.3 % of the standard. Therefore, the Project considered likelihood of public health impact from loud noise during the construction period to be moderate (3 points).

2. Severity of consequences

Construction workers and Project employees: Regarding the health impact on construction workers and Project employees, although construction activities last for a short period of time, the severity of impact is moderate (2 points) because loud noise may result in temporary or permanently loss of hearing, absence from work and may affect construction activities and production process.

Local residents in the vicinity: The prediction on the level of loud noise and noise reveals that the value of loud noise level caused by construction activities at Chumchon Borisat Namtan Tawan-aok School, Child Development Center of Chomphon Chao Phraya Sub-district Municipality, Wat Chomphon Chao Phraya and The Proud Village was 51.3-56.8 dB(A)). When combined this value with the maximum 24-hr average value from the monitoring (53.7-65.6 dB(A)), the value is equal to 56.2-66.0 dB(A) which is within the noise level standard of general noise not to exceed 70 dB(A).

In addition, the values of specific noise level at all 4 sensitive receptors were between 3.6-23.2 dB(A) which were higher than the standard value. However, since the project had installed temporary barriers to block noise during the construction period at the locations of foundation piling in the northeastern and southern areas of the project, the maximum value of specific noise level was reduced to 9.9 dB(A). Therefore, the study considers the severity of consequences of public health impact to be moderate (2 points) because of likelihood of impact to communities in the area.

(e) Assessment of the level of health risk

Construction workers and project employees: Regarding health impact on construction workers and project employees, although construction activities last for a short period of time, they may result in injuries or accumulation of risk groups and therefore, the severity of impact is moderate (2 points) and the likelihood of impact is moderate (3 points). Also since construction workers and project employees work in the areas where there are operations of heavy machineries as part of construction activities all through the work hours, the significance of impact is moderate (6 points) which is an acceptable level provided that there are mitigation and preventive measures for the impact or improvement of the existing measures.

Local residents in the vicinity: In terms of health impact, some people still live in the areas around the Project and the areas around the Project cannot accommodate much more noise. As such, the noise level of the project's construction is likely to affect the communities so the severity of impact is moderate (2 points) and the likelihood of impact is moderate (3 points). The significance of impact is also moderate (6 points) which is an acceptable level provided that there are mitigation and preventive measures for the impact or improvement of the existing measures.

(3) Trash and solid waste from construction activities and waste water(a) Characteristics of health impact

Solid waste generated during the construction period includes scrap materials from excavation, leftover structural parts, hazardous waste such as batteries and lubricant oils, and general waste amounting to 2,720 kg/day generated by 3,200 workers at maximum (based on the general standard that people generally produce approximately 0.85 kg of waste/person/day). These solid waste, if left to contaminate the environment, it may become the source of animal disease carriers, may release unpleasant odors and may cause conflicts with existing communities.

Waste water from consumption is approximately 179.2 m³/day generated by 3,200 workers at maximum (the quantity of waste water is approximately 80 % of the need of water for consumption at 70 L/person/day (Kriangsak, 1996).

(b) Major activities causing health impact

These wastes come from construction activities and daily consumption by construction workers and project employees.

(c) Risk groups

Risk groups that may receive health impact include construction workers and people living near the construction site.

(d) Likelihood of health impact and severity of consequences

1. Likelihood of health impact

Construction workers and project employees: Construction workers and project employees who are responsible for collecting general waste and gathering waste are the group with highest chances of contact. However, the project requires sorting of different types of waste as an initial stage as well as storing of waste according to Ministry of Industry's Notification re: Disposal of Waste or Discarded Materials B.E. 2548. In addition, the Project requires that employees use personal protective equipment (PPE) such as rubber gloves and protective suits according to occupational health, safety and environment measures. However, given that during the construction period, the Project will have up to 3,200 works and 2,720 kg of waste/day, this may affect the management of waste by local administration agencies and may cause accumulation of waste. Therefore, the Project considers the likelihood of health impact on employees to be moderate (3 points).

People living within a 5 km radius from the Project area's

boundary: During the construction period, the project allocates specific areas to store general waste and each type of waste and provide containers suitable for different types of waste for convenient and appropriate disposal. Trash is collected by local administrations while the project's solid waste is sent to be disposed by a company licensed by the Department of Industrial Works.

Regarding waste water of approximately 179.2 m³/day, waste water from toilets is collected to be treated through waste water treatment system until it meets the standard of discharged water.

Therefore, the Project considers the likelihood of public health impact to be moderate (3 points).

2. Severity of consequences

Construction workers and project employees: The Project considers the severity of consequences of impact on construction workers and Project employees including operation staff to be moderate (2 points) as they have chances of direct contacts which can cause health impact.

People living within a 5 km radius from the project area's boundary: During the construction period, it is estimated that the following amount of trash, construction waste and waste will be generated:

Trash approximately 2,720 kg/day.

Construction material scraps such as broken bricks, structural parts and discarded materials.

Hazardous waste such as batteries, lubricant oils, hydraulic oil and cleaning substances.

The project allocates specific areas to store waste and sort different types of waste and provide containers suitable for different types of waste for convenient and appropriate disposal.

Therefore, the project considers the severity of consequences of impact to the general public to be moderate (2 points) because the impact may increase

morbidity rate, cause injuries and accumulation of risk groups, affect budgets, result in absence from work, affect production and communities in the areas.

(e) Assessment of the level of health risk

Project employees: Regarding the significance of health impact, the likelihood of impact caused by general waste and solid waste on employees who are responsible for collecting and transporting these is moderate (3 points) because the employees and project employees who are responsible for collecting and gathering waste are the group with highest chances of contact. However, the project requires sorting different types of waste and storing waste according to the Ministry of Industry's Notification re: Disposal of Waste or Discarded Materials B.E.2548. In addition, the Project requires that employees use personal protective equipment (PPE) such as rubber gloves and protective suits according strictly to occupational health, safety and environment measures. The severity of impact is moderate (2 points). Therefore, the significance of health impact on Project employees is moderate (6 points) which means the Project must implement sufficient monitoring measures and additional measures to correspond with the impact.

Local residents in the vicinity: Regarding the significance of health impact, the likelihood of impact caused by general waste and solid waste on Local residents in the vicinity is moderate (3 points). The Project considers the severity of impact to be moderate (2 points). Therefore, the significance of health impact on Local residents in the vicinity is moderate (6 points) which is an acceptable level provided that there are mitigation and preventive measures or improvement of the existing measures.

(4) Transportation

(a) Characteristics of health impact

During the construction period, there are transportation of materials, equipment and tools used in construction and transportation of workers to the project area. All these may affect transportation in the project area and the vicinity. Besides, the occurrence of accidents may result in injuries and loss of life.

From the assessment of impact on transportation, the condition of highway used for transportation or Rural Highway No. Ror Yor.0403 is smooth. Transportation of materials and equipment during the construction period of the project does not affect the traffic on the project's transporting route. Besides, the construction contractors must strictly follow traffic laws. The Project must inform in advance to concerned authorities such as local police and community leaders about the transportation of materials, equipment and heavy machineries so that they can facilitate transportation. The community members will also be notified in advance every time for the safety of workers and commuters who used the same routes with the project.

(b) Project activities causing health impact

Transportation of materials and equipment for construction and transfers of construction workers and project employees.

(c) Risk groups

Risk groups that may be affected by road accidents during the construction period include people who commute around the project area and construction workers and project employees who do not reside in the construction site but travel to work daily on the same routes as the routes used by people living in the vicinity.

(d) Likelihood of health impact and severity of consequences

1. Likelihood of health impact

Construction workers and project employees: who work during the construction period, who do not reside in the construction site but travel to work daily on the same routes as the routes used by people living in the vicinity have chances of have road accidents. However, since the Project implemented mitigation measures, the likelihood of impact is low (2 points), meaning low probability, tendency to have impact, and mitigation measures are in place.

Local residents in the vicinity: According to the prediction of the traffic volume in Section 4.3.2 Transportation, Chapter 4 traffic volume is not different from the previous volume – the traffic flows smoothly. The traffic route is able to accommodate an increase in traffic volume. However, since the project still needs to use the same routes as the routes used by local residents and whereas the information from a public health agency reveals that accidents including road accidents are one of the major causes of morbidity in the study area. Therefore, the project considers the likelihood of public health impact to be low (2 points), meaning low possibility and mitigation measures are in place.

2. Severity of consequences

Construction workers and project employees: who work during the construction period may experience road accidents that may be severe and cause loss of life. Therefore, the Project considers the severity of impact to be high (3 points), meaning there are injuries, absence from work, effects on work performance or loss of life.

Local residents in the vicinity: Since the pre-construction and the construction activities last 51 months and the causes and mortality rate of local residents are mainly accidents, commuting of employees and workers of the Project and transportation may result in mild injuries, disability or loss of life. Therefore, the severity of public health impact is considered to be high (3 points), meaning severity to the extent of injuries or loss of life and impact on communities in the areas.

(e) Assessment of the level of health risk

Construction workers and project employees: Regarding the significance of health impact on construction workers and project employees, the impact is short term but its severity is high (3 points) and the likelihood is low (2 points). Therefore, the significance of impact is moderate (6 points) that is an acceptable level however, it requires mitigation and preventive measures or improvement of the existing measures.

Local residents in the vicinity: Regarding the significance of health impact on people who use the same traffic route as the routes used by the project, the impact is short term but its severity is high (3 points) and the likelihood is low (2 points). Therefore, the significance of impact is moderate (6 points), meaning it may cause injuries and may affect budgets, and it requires sufficient and appropriate monitoring on the existing mitigation and preventive measures.

(5) Socio-economic

The opportunity to hire local residents is estimated to be moderate (3) because the recruitment of workers during the construction period is the responsibility of the contractors. Therefore, the benefits from employment opportunity that local residents can receive depends on the contractors. However, environmental impact mitigation and preventive measures specify that the contractors consider hiring local residents as much as they can to reduce impact in terms of immigrated workers and to increase benefits for the

community. Local residents also request local hiring first to increase the flow of the community's economic system and to reduce unemployment rate for better livelihood of local residents which will encourage people to pay more attention to their own health with more choices for better healthcare services. It is estimated that the benefit that local residents will receive from employment opportunity is moderate (2). Therefore, the significance of impact on employment opportunity for local residents is moderate (6) which is an acceptable level, however, it requires mitigation and preventive measures or improvement of the existing measures.

(6) Occupational health, safety and environment

(a) Characteristics of health impact

During the construction period, construction activities such as welding, short circuits in electrical tools, construction in confined space, work with noise, in bright or low light areas, work with heat, contact with chemicals and incorrect body postures during work may cause accidents and injuries. All these may contribute to occurrences of injuries or dangers to life of workers.

From the impact assessment, the project is aware of the importance of occupational health, safety and environment of project employees and construction workers and have organized regular safety monitoring, orientation trainings and compliance with occupational health, safety and environment measures for workers to ensure safety all through the operation time. The project's major goal is zero accident.

(b) Project activities causing health impact

During the construction period, activities that may cause health impact include the following:

- Particulates matter generated from construction activities, transportation of materials out from construction site and transportation of project employees and construction workers;

- Exhaust gases from vehicles used in construction activities to transport materials and machineries/equipment and to move construction materials/parts;

- Loud noise and vibration from operations of various machineries used in the Project's construction activities;

- Occupational environment such as heat during the work hours, low or bright light, working in confined space, working at heights, working with loud noise and ergonomics injuries.

(c) Risk groups

Risk groups that may receive health impact from work include construction workers and project employees specifically, those carrying out work that requires special caution and protections such as structural setting in specific and difficult points to control machineries which only highly experienced workers should be employed and those who do maintenance of various machineries.

(d) Likelihood of health impact and severity of consequences

1. Likelihood of health impact

Construction workers and project employees: During the construction period, accidents from construction activities such as constructing at heights, in confined spaces, in loud areas, in bright or low light areas and with heated and incorrect ergonomics may occur and lead to injuries or dangers to life.

However, Sriracha Power Plant is aware of the importance of occupational health, safety and environment to ensure the highest safety all through the operation time. The project's major goal is zero accident. Therefore, the project considers the likelihood of health impact on construction workers and project employees to be moderate (3 points), meaning the existing statistical data supports the prediction of the likelihood.

2. Severity of consequences

Construction workers and Project employees: In case construction contractors do not pay sufficient attention or aware of the safety of construction workers, accidents may occur during work. The severity from accidents may result in injuries or loss of life of construction workers. Therefore, the project specifies the severity of impact to be high (3 points), meaning there are injuries, loss of life, expenses for recovery and effects on production.

(e) Assessment of the level of health risk

Construction workers and project employees: The level of health risk of construction workers and project employees is 9 points which is medium
and acceptable however, it requires mitigation and preventive measures or improvement of the existing measures.

(7) Public Health System

(a) Characteristics of health impact

Accidents and illness caused by project activities, including transportation of materials, equipment, machineries and employees, employees work accidents and emergencies, result in injuries and loss of life. From the interviews with health service officers in the area, 94.4 % of interviewees indicate that there are not enough personnel in the area. Personnel in need include professional nurses, dentists/dental hygienists and public health technical officers/public health officers. 77.8 % of the interviewees indicates that medical equipment at the public health offices in the area are not sufficient. Medical equipment in need include dental equipment, breathing ventilators and wound care supplies. It is possible that the project may increase burden to public health offices in the area as the current study area still lacks medical personnel in sub-district health promoting hospitals and government hospitals. However, the total number of medical personnel in private hospitals, Somdej Hospital (which has a lot of medical students), and sub-district health promoting hospitals and government hospitals, the study area is short of dentists only. Immigrated workers may access services from public health service offices and public health personnel in the area. Likewise, they may carry foreign diseases the local area.

However, the project has implemented appropriate action plans regarding occupational health, safety and environment and organized strict assessment and monitoring of practices according to occupational health, safety and environment of the Project. Also the Project will provide a first aid room for treating minor injuries to employees to reduce burden of the public health service offices in the area, screen job applicants' health before offering employment and conduct annual health check-up for employees to promote employees' health and to support medical personnel in the area for effective diagnosis and treatment of diseases.

(b) Project activities causing health impact

Accidents from construction activities and migration of construction workers and project employees to reside in the area.

(c) Risk groups

Major risk group is people living in the vicinity.

(d) Likelihood of health impact and severity of consequences

1. Likelihood of health impact

Local residents in the vicinity: During the construction period, the maximum number of workers/employees who travel to the area is 3,200 which increase likelihood of diseases and accidents in the area of medical personnel and medical equipment shortage. Therefore, the project considers the likelihood of impact on the service system to be moderate (3 points).

2. Severity of consequences

Local residents in the vicinity: In case construction contractors do not pay sufficient attention or aware of the safety of construction workers, accidents during work or epidemic may occur. Therefore, the project specifies the severity of impact to be moderate (2 points), meaning increase in morbidity rate, occurrence of injury, accumulation of risk groups, effects on budgets, absence from work, effects on production and effects on communities in the area.

(e) Assessment of the level of health risk

The likelihood of impact on people living in the vicinity is moderate (3) and the severity of impact is moderate (2). Therefore, the risk of impact is moderate (6) which is an acceptable level, however, it requires mitigation and preventive measures or improvement of the existing measures.

(8) Increase of Foreign Workers

(a) Characteristics of health impact

Foreign workers who come to perform activities during the construction period may, without proper screening or good and effective management, contribute to epidemic such as diarrhea, sexual transmission diseases and foreign diseases and social problems such as drug addiction, decrease in social safety and conflicts with local communities. Moreover, if foreign workers are injured or suffer work injuries and need to be delivered to a hospital or local health service office, the community's public health service system may be overcrowded which results in insufficiency of the public health service system.

(b) Project activities causing health impact

An increase of foreign workers during the Project's construction period amounting to 3,200 persons.

(c) Risk groups

People living within a 5 km radius from the project area's

boundary.

(d) Likelihood of health impact and severity of consequences

1. Likelihood of health impact

Local residents in the vicinity: During the construction period, the Project needs 3,200 employees and contractors per day. If all of them are non-local, it may cause social and public health problems because construction contractors are required to provide accommodation for the workers outside the project area which may pose risks in terms of contagious diseases, drug addiction, crime and insufficiency of public health services that affect local residents. In addition, from the opinion survey conducted with public health officers, the study area still lacks public health personnel in many fields such as doctors, nurses, dentists and public health officers. Moreover, 72.2 % of public health officers thought that, at the moment, social problems and crime such as robbery, drug addition, fighting and teen pregnancy already existed in the area.

Therefore, the Project considers the likelihood of public health impact to be moderate (3 points), meaning moderate probability with existing statistical data to support the prediction of the possibility.

2. Severity of consequences

Local residents in the vicinity: Since there will be 3,200 construction workers during the construction period, without proper screening of foreign workers or effective management, this may result in occurrences of epidemics which can affect the public health system in the area as well as social problems such as drug addiction, crime and safety of life and property. At the moment, existing problems in the study area include gambling, drug addiction, burglary and robbery. So, the Project will provide training to workers on sanitation, disease prevention and drug issues and require that contractors comply with labor laws regarding risk-based health and physical checkup and to keep records of the names of workers and headcount and medical conditions for

submission to responsible public health service offices to find solutions to reduce and prevent the problems.

Therefore, the Project considers the severity of consequences of public health impact to be moderate (2 points) meaning in case of fighting or robbery committed by the Project's workers, it may result in loss to people.

(e) Assessment of the level of health risk

Local residents in the vicinity: The level of public health risk is assigned 6 points which is medium and an acceptable level, however, it requires mitigation and preventive measures or improvement of the existing measures.

(9) Mental impact

(a) Characteristics of health impact

Transportation of materials, equipment, heavy machineries and transportation of workers contribute to an increase in traffic volume in the Project area which may cause a delay of travel of local residents. Also, it increases the risk of occurrences of road accidents, stress from traveling and anxiety on risks of road accidents.

The Project's construction may need to hire foreign workers whose way of life may differ from that of local residents which may cause conflicts. Also, the Project's various activities that generate particles, loud noise from activities and operations of machineries contribute to an increase of stress and anxiety of local residents in the vicinity. Although the tendency of mental disorders suffered by people in Chonburi and Rayong Provinces has risen, the review of records of outpatient (Ror Ngor. 504) shows that mental disorders (psychoneurosis) are not the major cause of illness of local residents in the study area.

(b) Assessment of the level of health risk

According to the data of mental disorders in Chonburi and Rayong Provinces, mental disorders are likely to increase. Although there are no mitigation and preventive measures for impacts on mental and living conditions of local residents, the Project will publicize construction plans to the communities and build confidence among the communities regarding the contractors' controls over the operations. This is to reassure the communities that all measures specified in the Environmental Impact Assessment Report will be strictly followed. The measures are an integral part of the contracts entered into with the construction contractors. It is anticipated that the impact will be limited within the Project area and the impact is moderate (3) and the severity is moderate (2). Therefore, the significance of impact on mental and living conditions of local residents is moderate (6) which is an acceptable level, however, it requires mitigation and preventive measures or improvement of the existing measures.

Operation Period

Project operations may pose health threats on workers and people in the sensitive receptors within a 5 km radius from the project area. The threats include changes of air quality conditions, noise, issues on occupational health, safety and environment, waste and hazardous waste. The characteristics of impact and risks of occurrence of impact are as follows.

(1) Air quality

(a) Characteristics of health impact: During the operation period, the project used natural gas as a primary fuel and diesel as a backup fuel. Pollutions that are harmful to health released by the power plant are Nitrogen oxides (NO_x), Sulfur dioxide (SO₂) and Total suspended particulates (TSP) which can affect human respiratory system. NO₂, when inhaled, may cause irritation to the air sac in the lung with symptoms similar to obstructive airway disease, especially with people with asthma. Inhaling SO₂ of 210 μ g/m³ directly will cause malfunction of the respiratory system. Inhaling SO₂ of 290 μ g/m³ will increase the pulse, slow breathing, increase of resistance in lungs and decrease mucus and the size of nasal holes (Wongpan Limpaseni, 1995). Impact on health depends on various factors such as the length of time of exposure, health conditions of the affected persons and concentrations of the pollutions. Details are shown in Table 5.1.3.2-1 and Table 5.1.3.2-2

The assessment of ambient air quality using mathematical model AERMOD in 6 scenarios (Details are shown in **Chapter 5, Air Quality**) is as follows:

Scenario 1: Impact from Sriracha Power Plant when natural gas is used as fuel and operated at 100 % load.

Scenario 2: Impact from Sriracha Power Plant when natural gas is used as fuel and operated at 60 % load.

TABLE 5.1.3.2-1

IMPACT FROM FUEL COMBUSTION ON HUMAN HEALTH

Pollutant	Impact on Health					
Sulfur Dioxide	• Inhalation of high level of SO_2 (Gaseous SO_2) even in short term will cause					
(SO ₂)	temporary difficulty in breathing to asthma patients or those who work outdoor.					
	Exposure to SO_2 or SO_2 particles will cause respiratory disease and aggravate					
	existing heart disease.					
	- Inhalation of SO_2 particles, SO_2 will interact with other chemicals in the air and					
	cause particles of sulphate. When inhaled, these particles will accumulate in lung					
	and irritate respiratory system, cause difficulty in breathing and other respiratory					
	diseases and premature death.					
	- Decrease visibility; when light is absorbed by SO_2 particles, the particles will reduce					
	visibility.					
Total Suspended	• Aggravate respiratory symptoms, e.g. respiratory irritation, cough, or difficulty in breathing;					
Particulates (TSP)	Deteriorate lung performance;					
	Aggravate asthma;					
	Cause chronic bronchitis;					
	Cause cardiac arrhythmia;					
	Cause heart problem, e.g. heart failure; and					
	Cause premature death in patients with heart or lung diseases					
Nitrogen oxides	- Nitric oxide (NO) and Nitrogen dioxide (NO $_2$) are hazardous compounds for humans.					
(NO _x)	Inhalation of NO $_2$ at 140 μ g/m 3 can reduce visibility in dark area (Wongphan					
	Limpaseni, 2543). NO_2 can aggravate asthma patients if inhaled at the					
	concentration of 190 μ g/m ³ together with Bronchoconstrictor. Respiratory disorder					
	in normal people can occur when inhaling the gas at the concentration of 1,300-					
	3,800 $\mu\text{g}/\text{m}^3$ and when compare acute impact on lung between NO and NO_2, NO is					
	obviously less dangerous.					
	- Can produce surface ozone (smog) from interaction between NO_{x} and Volatile					
	Organic Compounds or VOCs, catalyzed by sunlight. Risk groups comprise of					
	children, elders, asthma or bronchitis patients, and people who work outdoor.					
	Long-term or continuous exposure will lead to the deterioration of lung					
	performance. Ozone can be blown far from its source and affect people or					
	environment in the distance. It can also contribute to lower agricultural production.					
Nitrogen oxides	- Climate change. Nitrous Oxide (N_2O) which is in the family of nitrogen oxides can					
(NO _x)	cause greenhouse effect if accumulated in ambient air in high volume. Global					
(Cont'd)	temperature will gradually increase, sea level will rise. This will be very risky for					
	humanities since it will cause dramatic changes to flora and fauna.					
	• Toxic NO_x interact with other substances, particularly organic substances or					
	ozone and become a new toxic compound. Some of which are the cause of					
	biological mutation. Nitrate Radical, Nitroarenes, and Nitrosamines, are some					
	examples of new toxic compounds occurred.					

Source : http://hpe4.anamai.moph.go.th/hia/airpollutant.php, 2010

TABLE 5.1.3.2-2

Concentration		Duration		
ug/m ³	Parts per	of gas	Reason	Bibliography
μεγπ	million (ppm)	exposure		
230	0.12	-	Odor 3 of 9 normal healthy men smell it 	Henschier <i>et al.</i> (1960)
230	0.12	-	• Most of 14 people smell immediately at the beginning of the test	Salamberidze (1967)
200	0.11	-	 26 from 28 people smell immediately at the beginning of the test 	Feldman (1974)
1,300-3,800	0.7-2.0	10 min.	Impact on lung performanceIncreased inhale and exhale resistance.	Suzuki & Ishikawa (1965)
190	0.1	1 hr/day	 Increase pulmonary flow resistance and narrowed respiratory tract of 13 out of 20 asthma patients 	Orehek <i>et al.</i> (1976)
560,000- 940,000	300-500	-	Cause fatal Pulmonary Edema or unconscious due to lack of oxygen	Grayson (1956)
94	-	-	 Impact on community When compared impact on two community groups who share the same religion but live in different cities and exposed to different concentration of gas, neither impact on lung performance nor a rise of respiratory patient in non-smokers were found at when NO₂ concentration was 43 µg/m3 in people living in city which is a control group. 	Choen <i>et al.</i> (1972)
≥940	0.50	1 hr.	 No appearance of acute respiratory disorder on house-keepers who use gas oven, when compared with those who use electric oven. 	US.EPA (1976 b)

IMPACT OF NITROGEN OXIDE ON HUMAN

Source :

Air Pollution Treatment Manual, Department of Industrial Works, 2004

Scenario 3: Impact from Sriracha Power Plant when natural gas is used as fuel and operated at 100 % load, combined with current impact from other industrial factories that have been approved in the report on environmental impact assessment but have not yet released any air substance, and from the power plants in the development plan by Gulf Group Company that are located within a 15 km radius from the Project location.

Scenario 4: Impact from Sriracha Power Plant when diesel is used as fuel and operated at 100 % load.

Scenario 5: Impact from Sriracha Power Plant when diesel is used as fuel and operated at 69 % load.

Scenario 6: Impact from Sriracha Power Plant when diesel is used as fuel and operated at 100 % load, combined with current impact from other industrial factories that have been approved in the report on environmental impact assessment but have not yet released any air substance, and from the power plants in the development plan by Gulf Group Company that are located within a 15 km radius from the Project location.

(b) Activities causing health impact

Release of air pollutants through the project's emission stacks.

(c) Risk groups

Local residents in the vicinity specifically risk groups that are sensitive to contacts with pollutants such as children, elderly and patients with chronic respiratory system diseases.

(d) Likelihood of health impact and severity of consequences

1. Likelihood of health impact

Local residents in the vicinity: The prediction of air quality using mathematical model AERMOD can be concluded as follows. In Scenario 3: Impact from Sriracha Power Plant when natural gas is used as fuel and operated at 100 % load, combined with current impact from other industrial factories that have been approved in the report on environmental impact assessment but have not yet released any air substance, and from the power plants in the development plan by Gulf Group Company that are located within a 15 km radius from the project location which covered 21 sensitive receptors, the values of concentration of air pollutants including NO₂, SO₂ and TSP in the

atmosphere are within the standard. When combined such values with the existing maximum values from the monitoring, the level of concentration of air pollutants is 22.88-97.85 % of the standard values.

The statistical data of illness of outpatient according to Ror Ngor.504 Report from hospitals in the study area during 2009-2013 shows that major causes of illness of local residents were respiratory system diseases, endocrine diseases, nutrition and metabolism disease and blood circulatory diseases, with the morbidity rate of 29,010, 27,110 and 24,469 per 100,000 populations respectively.

The outpatient morbidity statistics according to Ror Ngor.504 Report from sub-district health promoting hospitals (public health centers) during 2009-2013 shows that major causes of illness of local residents were symptoms, medical signs and abnormalities found in clinical examinations and laboratories that could be classified into any group of disease, respiratory system diseases and blood circulatory diseases, with the morbidity rate of 41,698 27,439 and 10,978 per 100,000 populations respectively.

The outpatient morbidity statistics according to Ror Ngor.505 Report of local residents during 2009-2013 shows that the cause of illness from respiratory diseases was not the major cause of illness of local residents. In fact, the major causes of illness were pregnancy complications from delivering single childbirth (normal), endocrine diseases and nutrition and metabolism diseases, with the morbidity rate of 1,940 1,237 and 1,058 per 100,000 populations respectively **(Details are shown in section 4.4.2 Health, Chapter 4)**.

According to the interviews regarding causes of illness of people in the current environment with public health officers in the study area, 72.2 % of public health officers stated that the current environment such as air quality, water quality and solid waste resulted in illnesses of local residents.

The data on current environment of the study area revealed that the vicinity can still accommodate more pollutants. However, given that the project will operate for a long period, there are chances of accumulation of pollutants. Therefore, the project considers the likelihood of public health impact to be moderate (3 points), meaning impact is likely to occur and strict control measures are required.

2. Severity of consequences

Local residents in the vicinity: The prediction of air quality using mathematical model AERMOD can be concluded that in Scenario 3: Impact from Sriracha Power Plant when natural gas is used as fuel and operated at 100 % load, combined with current impact from other industrial factories that have been approved in the report on environmental impact assessment but have not yet released any air substance, and from the power plants in the development plan by Gulf Group Company that are located within a 15 km radius from the Project location which covered 21 sensitive receptors, the values of air pollutants including NO₂, SO₂ and TSP in the atmosphere are within the standard. When combined such values with the existing maximum values from the monitoring, the level of concentration of air pollutants is within the standard. The maximum values are found at the mountain area which is 10-12 km away from the project area, at the area within the industrial estate and at nearby industrial estates 15 km away from the project area.

Therefore, the project considers the severity of consequences of impact on Local residents in the vicinity to be moderate (2 points), meaning it may affect people and increase illness caused from the rising quantity of air pollutants.

(e) Assessment of the level of health risk

Local residents in the vicinity: The values of released air pollutants including TSP, NO₂ and SO₂ are within the standard, therefore, the severity of impact is moderate (2 points). The statistical data on illness of local residents according to records of outpatient (Ror Ngor. 504) show that respiratory system diseases is the major cause of illness of local residents. In this regard, the project considers likelihood of public health impact to be moderate (3 points). Therefore, the significance of public health impact from contacts with TSP is moderate (6 points), meaning it requires monitoring of the existing environmental impact mitigation and preventive measures to determine if they are sufficient and appropriate.

(2) Noise

(a) Characteristics of health impact

Regarding noise impacts on health, hearing noise of 120 dB(A) or above will pose risk of deafness whereas hearing noise of 90 dB(A) or above for a period of 8 hr or more per day or hearing noise of 70 dB(A) or above all the time can pose risk of loss of hearing and reduction of hearing capability. Being exposed to noise on a regular basis may result in mental impact including stress effect on concentration, thinking, learning, efficiency and work efficiency.

During the operation period, the major noise source will be an electricity generator. The standard engineering design specifies that the noise level at 1 m away from the generator and 1.2 m above the ground (level of hearing) must not exceed 85 dB(A). Regarding the project's design, equipment generating loud noise will be installed in buildings that are equipped with acoustic walls to absorb noise. Silencers will be installed to reduce the noise level during operations of equipment that may generate loud noise, such as safety valves and start up vent valves, to limit the noise level in the workplace for the 8-hr average noise level standard not to exceed 90 dB(A) all through the work hours. Also, workers who work in the loud noise areas must use personal protective equipment (PPE), such as earmuff headbands, all through the work hours. The Project will control general noise level at the Project's fence areas not to exceed 70 dB(A). Sensitive receptors in the vicinity including Chumchon Borisat Namtan Tawan-aok School, Child Development Center of Chomphon Chao Phraya Sub-district Municipality, Wat Chomphon Chao Phraya and The Proud Village will be exposed to the noise level from the project, when combined with the maximum value from the measurement, of 53.9-65.6 dB(A) or equivalent to 77.0-93.7 % of the 24-hr average noise level standard. Regarding the prediction of noise using the 1-hr average specific noise level during 06.00 a.m. to 22.00 p.m. and using the 5-min average noise level during 22.00 p.m. to 06.00 a.m., the value ranges from non-disturbing level up to 9.9 dB(A). Details are shown in Impact Assessment, Section 5.1.1.2 Noise in Chapter 5.

(b) Project activities causing health impact

Noise from machineries and electricity generating equipment.

(c) Risk groups

Project employees who are categorized as a primary risk group and people living within a 5 km radius from the Project area's boundary as the secondary risk group.

(d) Likelihood of health impact and severity of consequences

1. Likelihood of health impact

Project employees: The likelihood of impact on the project's employees who work during the operation period is moderate (3 points) because they will be exposed to noise from operations all through the work hours.

Local residents in the vicinity: Regarding the assessment of significance of impact from loud noise during the operation period, taking into consideration impact on people living in the vicinity, the possibility of being exposed to loud noise from project operations is moderate (3 points) because the impact may occur for a long period of time.

2. Severity of consequences

Project employees: In terms of health impact on the project employees, the project requires that employees must use personal protective equipment (PPE), such as ear plugs or ear muffs, all through the work hours. The project also has implemented mitigation measures for noise impacts. However, since the employees work for a continuous period of time, the Project considers the severity of consequences on project employees to be moderate (2 points), meaning possible injuries and accumulation of risk groups.

Local residents in the vicinity: The prediction of the level of general noise shows that in all 4 sensitive receptors near the Project, the noise level of activities relating to electricity generation range between 38.9-43.0 dB(A). When combined this value with the current maximum level from the measurement of 53.7-65.6 dB(A), the noise level is not different from the current value from the measurement which is equal to 53.9-65.6 dB(A) and the 5-min average noise level during 22.00 p.m. to 06.00 a.m. is in non-disturbing level to 9.9 dB(A).

Therefore, the project considers the severity of consequences of public health impact to be moderate (2 points).

(e) Assessment of the level of health risk

Project employees: Regarding the assessment of significance of impact from loud noise during the operation period, taking into consideration impact on the project employees, the possibility of being exposed to loud noise from project operations is moderate (3 points), the severity of impact low (2 points) and the significance of impact moderate (6 points), meaning strict measures to prevent noise impacts are required.

Local residents in the vicinity: Regarding the assessment of significance of noise impacts during the operation period, taking into consideration impact on people living in the vicinity, the possibility of being exposed to loud noise from project operations is moderate (3 points), the severity of impact low (2 points) and the significance of impact moderate (6 points), meaning strict measures to prevent noise impacts are required.

(3) Trash and Hazardous waste

(a) Characteristics of health impact

Solid waste generated during the operation period can be classified into 2 types: solid waste from production process such as discarded materials and containers, used air filters, used lubrication oils for machineries, resin, dregs; and general waste from employees' activities such as waste from office buildings.

In case of environmental contamination, it may become the source of animal disease carriers, may release unpleasant odors and may cause conflicts with local communities.

(b) Project activities causing health impact

An increase of trash and solid waste from the project operations.

(c) Health impact risk groups

Project employees and local residents in the vicinity.

(d) Likelihood of health impact and severity of consequences

1. Likelihood of health impact

Project employees: The project employees who are responsible for collecting general waste and gathering waste are the group with highest chances of contact although the project requires sorting of different types of waste as well

as storing waste according to the Ministry of Industry's Notification re: Disposal of Waste or Discarded Materials B.E.2548. In addition, the project requires that employees use personal protective equipment (PPE), such as rubber gloves and protective suits and according to the occupational health, safety and environment measures. However, chances for the project employees to make contacts with hazardous waste remain. Therefore, the project considers likelihood of health impact on employees to be moderate (3 points) which requires strict prevention measures for contacts by employees.

Local residents in the vicinity: The project has implement measures for waste management system such as waste from office buildings must be gathered for the local agencies to collect and dispose. Lubrication oils, air filters and resin will be delivered to be disposed by a company licensed to dispose industrial waste by Department of Industrial Works.

Therefore, the project considers the likelihood of public health impact to be moderate (3 points) which requires strict prevention measures for contacts by employees.

2. Severity of Consequences

Project employees: The severity of consequences of impact on employees is moderate (2 points) because the employees and workers have chance of direct contacts which may cause injuries and may affect production.

Local residents in the vicinity: The increase of trash and solid waste mentioned above may pose dangers to health in case of direct contacts and accumulated hazardous substances in the body. However, the Project has implemented proper methods to collect and dispose trash and solid waste to potential prevent health impact to local residents around the Project.

Therefore, the project considers the severity of consequences of public health impact to be moderate (2 points).

(e) Assessment of the level of health risk

Project employees: The project employees have chances to have contacts with hazardous waste so the project considers the likelihood of contact to be moderate (2 points). In case of contacts, it will result in health impact so the project considers the severity to be moderate (3 points). Therefore, the significance of health impact on project employees is moderate (6 points), meaning it requires mitigation and preventive measures or improvement of the existing measures.

Local residents in the vicinity: Regarding the significance of health impact, the chance of contacts is moderate (2 points). In case of contacts, it will result in health impact so the project considers the severity to be moderate (3 points), Therefore, the significance of public health impact is moderate (6 points), meaning it requires mitigation and preventive measures or improvement of the existing measures.

(4) Transportation

(a) Characteristics of health impact

During the operation period, there will be transportation of chemical substances, gasoline and project employees to the project location which may affect transportation within and around the Project area. Moreover, the occurrence of accidents may result in injuries and loss of life.

The assessment of impact in terms of transportation shows that the highways used for transportation are in good conditions. Moreover, the transportation of materials and equipment during the Project's operation period will not affect the flow of traffic around the project area.

(b) Project activities causing health impact

Transportation of chemical substances, gasolines and employees and workers.

(c) Risk groups

Risk groups that may be affected by road accidents during the operation period include people who travel around the project area and the project employees who do not reside in project area but travel to work daily on the same routes as the routes used by people living in the vicinity.

(d) Likelihood of health impact and severity of consequences

1. Likelihood of health impact

Project employees: There are 60 employees who work during the operation period but do not reside on site as they travel daily to work on the same routes as the routes used by people living in the vicinity. Therefore, the likelihood of impact is moderate (2 points), the same level as the likelihood of impact on local residents in the vicinity.

Local residents in the vicinity: The prediction of the increase in traffic volume during the operation period in Section 4.3.2 Transportation, Chapter 4 shows that the traffic volume is not different from the current volume. Highway No.331, Rural Highway No. Chor Bor 3027, Highway No.3574 and Ror Yor 0403 are found to be highly smooth and they can accommodate the increased traffic volume. However, the project still needs to use the same routes to the routes used by local residents. Therefore, the project considers the likelihood of public health impact to be low (2 points), meaning low possibility and mitigation and preventive measures are required.

2. Severity of consequences

Project employees: For Project employees who work during the operation period, the project considers the severity of impact to be high (3 points), meaning possible injuries, absence from work, effects on work performance, and loss of life.

Local residents in the vicinity: The activities during the operation period last for a long period of time. Occurrence of accidents will bring about mild injuries up to disabilities or loss of life. Therefore, the severity of occurrences of public health impact is considered to be high (3 points), meaning possible injuries, effects on communities and loss of life.

(e) Assessment of the level of health risk

Project employees: Regarding the significance of health impact on project employees, the severity is high (3 points) and the likelihood is low (2 points). Therefore, the significance of impact is moderate (6 points), meaning it requires mitigation and preventive measures or improvement of the existing measures.

Local residents in the vicinity: Regarding significance of health impact to people who use the same routes as the routes used by the project, the severity is high (3 points) and the likelihood is low (2 points). Therefore, the significance of impact is moderate (6 points), meaning it requires mitigation and preventive measures or improvement of the existing measures.

(5) Socio-economy (Employment and Local Hiring)

The likelihood of benefits from employment is predicted to be moderate (3) because during the operation period, the project requires local hiring based on to the suitability of positions and responsibilities to reduce impact that may occur from foreign workers, to increase benefits for local communities, to increase employment status and to create jobs in the locality.

Employment and job creation in the locality will bring better quality of life and encourage people to take better care of their own health with more choices to receive better healthcare services. As such, the benefit for people in the communities is moderate (2). Therefore, the significance of impact from employment for local residents is moderate (6) and is classified as positive impact.

(6) Occupational health, safety and environment

(a) Characteristics of health impact

During the operation period, accidents and work injuries such as contacts with chemicals, exposure to loud noise, exposure to heat, fire outbreaks, explosions of steamers, leaks of oil tanks and other severe dangers may occur which may result in injuries, illness and dangers to life of the workers and people living in the vicinity.

Moreover, the activities during the operation period will last for a long period of time. Therefore, if project employees work in an inappropriate environment and they ignore to follow the project's occupational health, safety and environment rules, it may result in accidents during the work or it may accumulate effects to the extent that it causes work-related diseases.

(b) Project activities causing health impact

Activities during the operation period that may cause impact

include the following.

- Working with machineries
- Running office errands such as documentation, working with

computer, working in bright or low light areas

- Working with chemical substances

(c) Health impact risk groups

The risk group that may receive health impact from work is the project employees.

(d) Likelihood of health impact and severity of consequences1. Likelihood of health impact

Project employees: During the operation period, accidents and injuries from the project activities such as maintaining machineries, working in loud areas, working in bright or low light areas, working with heat and incorrect ergonomics, may occur which may result in injuries or dangers to life.

However, Sriracha Power Plant is aware of the importance of occupational health, safety and environment to ensure the highest safety all through the operation time. The project's major goal is zero accident. Therefore, the project considers the likelihood of health impact on project employees to be low (2 points), meaning low possibility with supporting data on the occurrences but the project already implemented environmental mitigation measures.

2. Severity of consequences

Project employees: In case workers do not appropriately pay attention or are not aware of work safety, accidents may occur during the operation. The severity from accidents may result in injuries or loss of life of project employees. Therefore, the project specifies the severity of impact to be high (3 points), meaning effects on life and very high expenses.

(e) Assessment of the level of health risk

Project employees: The level of health risk of the project employees is moderate (6 points) which requires mitigation and preventive measures or improvement of the existing measures.

(7) Public health service system

(a) Characteristics of health impact and health impact risk

groups

Accidents and illness caused by the project's activities, such as transportation of chemical substances, transportation of employees, accidents during work performance and unpredicted incidents will result in injuries and loss of life. All mentioned above will also increase burden of public health service offices in the areas and will affect local residents who also obtain services from the same public health service offices.

However, the project has implemented appropriate action plans regarding occupational health, safety and environment and organized strict assessment and monitoring of practices according to occupational health, safety and environment of the project. Also the project will provide a first aid room for treating minor injuries to employees to reduce burden of the public health service offices in the area, screen job applicants' health before offering employment and conduct annual health check-up for employees to promote employees' health and to support medical personnel in the area for effective diagnosis and treatment of diseases.

(b) Assessment of the level of health risk

The likelihood of impact is low (2). However, because the impact is a long term impact and the area is short of medical personnel and equipment, the project considers the severity of impact to be high (3). Therefore, the risk of impact is moderate (6) which is an acceptable level and must strictly follow the measures.

(8) Increase of foreign workers

(a) Characteristics of health impact

The arrival of 60 employees who may be from other areas, without proper screening or good and effective management, contribute to epidemic such as diarrhea, sexual transmission diseases and foreign diseases and social problems such as drug addiction, decrease in social safety and conflicts with local communities. Moreover, if foreign workers are injured or suffer work injuries and need to be delivered to a hospital or local health service office, the community's public health service system may be overcrowded which results in insufficiency of the public health service system.

(b) Project activities causing health impact

An increase of foreign workers during the project's construction period amounting to 60.

(c) Risk groups

People living within a 5 km radius from the project area's

boundary.

(d) Likelihood of health impact and severity of consequences1. Likelihood of health impact

Local residents in the vicinity: During the operation period, the project needs 60 employees/day. If all of them are from other areas, this may cause social and public health problems because construction contractors are required to provide accommodation for the workers outside the project area which may cause risks of occurrences of contagious diseases, drug addiction, crime and insufficiency of public health services that affected local residents. In addition, from the opinion survey conducted with public health officers, the study area is already facing drug addiction and robbery problems.

Therefore, the project considers the likelihood of public health impact to be moderate (3 points), meaning moderate possibility with existing statistical data to support the prediction of the possibility.

2. Severity of consequences

Local residents in the vicinity: In light of 60 employees during the operation period, in case of epidemics, it will affect the public health system in the area and can lead to social problems such as drug addiction, crime and safety of life and property. At the moment, the study area still has problems relating to gambling, drug addiction, burglary and robbery. So, the Project has implemented measures to hire local people who possess qualifications suitable to the company's requirements to reduce impact that will affect the relationship of people and local communities. Job applicants will undergo a health screening before offering of employment and an annual health check-up will be provided to employees to reduce these problems.

Therefore, the project considers the severity of consequences of public health impact to be moderate (2 points), meaning fight or robbery committed by the workers may result in people's loss.

(e) Assessment of the level of health risk

Local residents in the vicinity: Regarding the significance of impact from the increase of foreign workers, the likelihood of impact is moderate (3points) and the severity of impact is moderate (2 points). Therefore, the significance of impact is moderate (6 points), meaning it requires mitigation and preventive measures or improvement of the existing measures.

(9) Mental Health Impact

(a) Characteristics of health impact and Health impact risk

groups

The operation of project activities may result in anxiety and stress due to changes in air quality, unforeseeable incidents to the project, increase in road traffic in the project area delaying travel of local residents and increase risk of road accidents. Difference of cultures and ways of life of workers from other areas also increase mental problems. However, local hiring policy will alleviate the mentioned conflicts so the project requires that local people be hired according to the suitability of positions and responsibilities to reduce impact from foreign workers and to increase benefits for local communities.

(b) Risk Tolerance

Although there are no mitigation and preventive measures for mental health impact and living conditions of local residents, the Project has guidelines to support public to monitor the project operations specifically on environmental management of the power plant to reduce anxiety and to build confidence among the communities. Since it is predicted that the impact within the Project area will be a long term impact and the likelihood of impact is moderate (3) while the severity is moderate (2), the significance of impact on mental health and living conditions of local residents is moderate (6).

(10) Chemical substances

Chemical substances used in the project include acids, alkalis and substances for preventing accumulation of dregs in solid or liquid forms. Chemical leaks and residues will directly affect employees' health. Therefore, the consultant has assessed health impact or health risks caused by having contacts with chemical substances.

(a) Hazard Statements

Preliminary assessment of health risks involved a compilation of data from Material Safety Data Sheet (MSDS) of each chemical and data on health impact from U.S. EPA (www.epa.gov/iris). The project considered physical and chemical characteristics of each substance (details are shown in **Table 5.1.3.2-3**), chemical characteristics, channels of contacts and dangers from contacting with chemicals which can be summarized as follows (details are shown in **Table 5.1.3.2-4**).

(b) Dose-response Assessment

Dangers or illnesses from contacting with chemicals will occur if the amount of chemicals is sufficient. This is determined by the dose-response relationship derived from the study in guinea pigs to assess responses in human. Chemicals can be classified into 2 groups: non-carcinogen substances; and carcinogen substances in human. Chemicals used in the Project can be classified as follows.

1. Non-carcinogen substances

Sodium Chlorite

- Acute Oral Toxicity (LD₅₀) at concentration level of 165

mg/kg in guinea pigs

- Contacts by laboratory animals: The amount of Acute

Oral Toxicity eaten by guinea pigs (LD_{50}) at 165 mg/kg is lethal dose in 50 % of guinea pigs.

Ferric Chloride

- Acute Oral Toxicity (LD₅₀) at concentration level of 316

mg/kg in guinea pigs.

- Contacts by laboratory animals: The amount of Ferric

Chloride eaten by guinea pigs (LD_{50}) at 316 mg/kg is lethal dose in 50 % of guinea pigs.

Polymer

- Acute Oral Toxicity (LD₅₀) at concentration level of 3,500

mg/kg in guinea pigs.

- Contacts by laboratory animals: The amount of Polymer

Chloride eaten by guinea pigs (LD_{50}) at 3,500 mg/kg is lethal dose in 50 % of guinea pigs.

PHYSICAL AND CHEMICAL PROPERTIES OF CHEMICALS USED IN SRIRACHA POWER PLANT										
Chemical (Trade name)	Formula	Boiling point (°C)	Melting point (°C)	Vapor pressure (mm.Hg) at 20 °C	Specific gravity (water = 1)	Molecular weight	Auto- ignition temperature (°C)	Flash point (°C)	Water solubility (g/100 ml.)	Appearance of color and odor
1. Sodium Chlorite	NaClO ₂	-	180	-	2.5	90.45	-	-	\checkmark	Solid/White
2. Ferric Chloride	-	105-110	-	-	1.45	-	-	-	\checkmark	Liquide/Dark Red
3. Polymer	-	-	-	-	-	-	-	-	\checkmark	Solid/White/Odor
4. Sulfuric acid	H ₂ SO ₄	290	3	145.8	1.84	98.08	-	-	\checkmark	Liquid/Colorless/No Odor
5. Sodium Metabisulfite (SMBS)	Na ₂ S ₂ O ₅	_	150	-	1.4	190.13	_	_	\checkmark	Solid/Odor like Sulfur dioxide/ White or Light yellow
6. Kurifloat K-330 (Anti Scale)	-	-	-	-	-	-	-	-	-	Solid/White
7. Oxygen Scavenger	-	-	-	12	8.5-8.6	-	-	-	\checkmark	Liquid/ Colorless
8. Aqueous Ammonia	NH ₃	-	-100	115	0.880-0.957	35.05	-	-	\checkmark	Liquid/ Colorless /Odor
9. Trisodium Phosphate	Na ₃ PO ₄ . 12H ₂ O	-	-	-	-	-	-	-	\checkmark	Solid/ White or Colorless /No Odor
10. Corrosion Inhibitor and Scale Inhibitor	-	-	-	-	1.14-1.18	-	-	-	\checkmark	Liquid/Yellow-Brown
11. Sodium Hydroxide	NaOH	140	12	2.3	1.53	40	-	-	111 at 20 °C	Liquid/ Colorless /No odor
12. Citric Acid	C ₆ H ₈ O ₇	-	153	-	1.665	192.13	1,010	-	√	Liquid/ Colorless /No odor

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TABLE 5.1.3.2-3

Source : Sriracha Power Plant, 2015

MSDS, 2015

www.msds.orica.com

TADLE 5.1.5.2-4							
CHEMICAL EXPOSURE BY TYPE AND PATHWAY							
		Exp					
	Skin contact	Inhalation					
	\checkmark	\checkmark					
	\checkmark	\checkmark					

	Exposure pathway					
Chemical (Trade name)	Skin contact	Inhalation	Ingestion or	Eye contact		
			swallowing			
1. Sodium Chlorite	\checkmark	✓	\checkmark	\checkmark		
2. Ferric Chloride	\checkmark	\checkmark	\checkmark	\checkmark		
3. Polymer	\checkmark	\checkmark	\checkmark	\checkmark		
4. Sulfuric acid	\checkmark	\checkmark	\checkmark	\checkmark		
5. Sodium Metabisulfite (SMBS)	\checkmark	\checkmark	\checkmark	\checkmark		
6. Kurifloat K-330 (Anti Scale)	\checkmark	\checkmark	\checkmark	\checkmark		
7. Oxygen Scavenger	\checkmark	\checkmark	\checkmark	\checkmark		
8. Aqueous Ammonia	\checkmark	\checkmark	\checkmark	\checkmark		
9. Trisodium Phosphate	\checkmark	\checkmark	\checkmark	\checkmark		
10. Corrosion Inhibitor and Scale Inhibitor	\checkmark	\checkmark	\checkmark	\checkmark		
11. Sodium Hydroxide	\checkmark	\checkmark	\checkmark	\checkmark		
12. Citric Acid	\checkmark	\checkmark	\checkmark	\checkmark		

TABLE 5.1.3.2-4

Source : Sriracha Power Plant, 2015

MSDS, 2015

www.msds.orica.com

Sulfuric Acid (H₂SO₄)

- Acute Oral Toxicity (LD₅₀) at concentration level of 2,140

mg/kg in guinea pigs.

- Acute Toxicity of the Dust $(LC_{50})^{1/}$ at concentration level

of 510 mg/m 3 for 2 hr.

- Contacts by laboratory animals: The amount of Sulfuric Acid eaten by guinea pigs (LD_{50}) at 2,140 mg/kg is lethal dose in 50 % of guinea pigs, and at concentration level of 510 mg/m³ for 2 hr is lethal dose in 50 % of guinea pigs.

Sodium Metabisulfite (SMBS)

- Acute Oral Toxicity (LD₅₀) at concentration level of 1,131

mg/kg in guinea pigs.

- Contacts by laboratory animals: The amount of Sodium

Metabisulfite eaten by guinea pigs (LD_{50}) at 1,131 mg/kg is lethal dose in 50 % of guinea pigs.

Kurifloat K-330 (Anti Scale)

- Acute Oral Toxicity (LD₅₀) at concentration level of 7,400

mg/kg in guinea pigs.

- Contacts by laboratory animals: The amount of acute

toxicity eaten by guinea pigs (LD_{50}) at 7,400 mg/kg is lethal dose in 50 % of guinea pigs.

Aques Ammonia

- Acute Oral Toxicity (LD50) at concentration level of 350

mg/kg in guinea pigs.

- Contacts by laboratory animals: The amount of acute oral

toxicity eaten by guinea pigs (LD_{50}) at 350 mg/kg is lethal dose in 50 % of guinea pigs.

Trisodium Phosphate

From data from MSDS, the substance causes irritation on body when having direct contacts, but there is no data from the study in laboratory animals and effects to human.

Sodium Hydroxide (NaOH)

From data from MSDS, the substance causes abrasion and irritation on the body when having direct contacts, but there is no data from the study in laboratory animals and effects to human.

 $^{^{1/}}$ The concentration of chemical substances in the air which was predicted to make guinea pigs that inhaled the substances during the specified periods died at half (50 %) of the original amount.

Citric Acid

mg/kg in guinea pigs.

Acute oral toxicity (LD_{50}) at concentration level of 3,000

Contacts by laboratory animals: The amount of acute toxicity eaten by guinea pigs (LD_{50}) at 3,000 mg/kg is lethal dose in 50 % of guinea pigs.

2. Carcinogen substances

There is no finding of carcinogen substances according to International Agency for Research on Cancer (IARC).

(c) Characteristics of health impact and Health impact risk groups

To determine the channels and methods of receiving chemical substances into the body, the consultant considered contacts of chemicals by employees on duty, characteristics of work and maintenance procedures for chemical distribution tubes in case of emergency which must be corresponded with physical and chemical qualifications of each chemical type. From a review in Chapter 2 regarding characteristics of operation activities with risks of contacts with chemicals, some activities require contacts with chemicals such as transportation of chemicals, using of chemicals in procedures for improving water quality and procedures for waste water treatment. The project employees or workers who are nearby have chances to contact chemicals through inhaling, skin and eye. Also, accidental ingestion of chemicals may cause symptoms of irritation and rashes on the contacted organs along the passage. Ingesting chemicals by accidents during work performance may cause symptoms of stomachache, nausea and vomiting.

However, the project's occupational health, safety and environment measures specify that employees must use personal protective equipment (PPE) that is suitable to the type of work performance. The equipment includes dust masks or respiratory protection masks, safety gloves, chemical protective suits, safety goggles, safety shoes, face protection masks and eye protector glasses. In addition, the project provides washing spots in the chemical storage areas and in the areas where chemicals are used. In the chemical storage areas, the chemical safety documents (MSDS) and equipment sets will be in place in case of chemical leaks, consisting containers to collect chemicals and chemical absorbents. Furthermore, the Project gives trainings on safety in workplace including building awareness of work hazard.

(d) Risk Tolerance

From the project's occupational health, safety and environment measures, the likelihood of impact from chemical substances on employees' health is moderate (3). The severity of impact is high (3) because chemicals can enter the body through many channels including skin, inhaling, ingesting and through the eyes, which can cause dangers to employees at any time. Therefore, risks relating to contacts with chemicals is moderate (9) which is an acceptable level, however, it requires mitigation and preventive measures or improvement of the existing measures.

Mitigation Measures

(1) Construction Period

Public Health

• Provide a first-aid unit, basic medication, and transporting vehicle in case of emergency in the construction area in accordance with Ministry of Labour's Notification re: Provision for Welfare in the Business Premises, B.E.2548.

- Provide clean drinking water for workers.
- Provide toilets that meet the public hygiene principle with the ratio of 15 workers per toilet.

• Train workers on health and hygiene, disease prevention, behavior to avoid causing disturbance, drugs.

• Ensure the contractors comply with labor laws regarding physical health check and risk-based heath check.

• Prepare a list of construction workers, report the number and their chronic diseases to the public health station responsible for the area prior to coming to work.

• Provide training to workers and employees on the knowledge of health and action in case of serious accident or emergency prior to commencement of the construction.

• Provide hygienic sanitary environment in the construction workers' living quarters and the construction site.

- Use strict security system in the construction workers' living quarters.
- Monitor contagious disease jointly with the local public health agencies.

• Supervisor and ensure that the contractors comply with the contract such as monitoring workers' living quarters, random drug test, garbage sorting in the workers' living quarters in accordance with the principle and methods of for garbage management.

• Provide channel of complaints through the Environmental Impacts Monitoring Committee.

• Ensure that the contractors coordinate with schools especially kindergarten to primary education level at least 6 months prior to the project construction in the case some workers need to enroll their children in the local schools.

Occupational Health, Safety and Environment Measures on General Safety

• Specify occupational health and safety measures in the agreement, requiring the contractors to do as follow:

- The project specifies in the contract that the contractors and the operation team working within the power plant under the contracts shall implement occupational health, safety and environment measures in their design, construction and operation to comply with the occupational health and safety standards, rules and regulation.

- The project shall provide competent personnel to be in charge of occupational health, safety and the environment.

- The project and the main contractors shall establish an Occupational Health, Safety and Environment Committee (OHS Committee) that also consists of heads of subcontractors. The Chairman of the OHS Committee will report directly to the project manager. The OHS Committee shall hold a meeting at least once a month to assess the results and make suggestions for corrective actions.

- The project shall provide a first-aid unit, basic medication, and transporting vehicle in case of emergency in the construction area in accordance with Ministry of Labour's Notification re: Provision for Welfare in the Business Premises, B.E.2548.

- The project shall require inspection of personal protective equipment regularly or as specified in the Safety Procedure.

Risks Mitigation Measures

• The steam production unit must have a steel structure with walking ramps and stairs for going up and down to enter the office safely.

• Install insulation on the steam and hot water pipes for the safety in carrying out work.

• Installation of equipment and construction will be carried out by reliable and experienced contractors with the safety officer supervising the safe conducts. Inspect and test the equipment and the construction by the engineer to ensure they meet the standard.

• Inspect safety of the steam producing unit and to test the safety valves under the supervision of the engineer licensed for inspection of the boilers in accordance with the Engineering Profession Act, before commissioning.

Fire Prevention and Fire System

• The main contractors must provide sufficient fire equipment for the persons working in the dangerous area or working with heat and exposed to fire. For example, in welding work, welding team must have a dry chemical fire extinguisher near the place of work. For welding at height, insulation lining must be placed underneath to prevent sparks from welding from catching fire underneath otherwise it is unsafe for persons working underneath the place of welding.

• The main contractors must establish plans to coordinate with the local fire department in case of emergency.

• Control of the entrance and exit of the dangerous zone where the construction works are performed, control of the traffic, install warning clear signs by the supervisor in charge or by the safety officer.

• Inspect function and condition of equipment to be used in the construction, especially at the places exposing to danger or fire.

• Inspect the working of the fire equipment regularly as specified in the Safety Procedure.

(2) Operation Period

Public Health

• Provide a first-aid unit, basic medication, and transporting vehicle in case of emergency in the construction area in accordance with Ministry of Labour's Notification re: Provision for Welfare in the Business Premises, B.E.2548.

• Provide pre-employment physical check-up and annual physical check-up.

• Organize activities to promote good health and educate communities on environment and good health.

• Support public health agencies in the area in promotion, rehabilitation, prevention and health care for the community.

• Survey the statistic of illness of the people within 5 km radius from the project. Occupational Health, Safety and Environment

• Establish an Occupational Health, Safety Committee to oversee the work. Organize OHS meetings at least once a month to evaluate and make suggestions to correct problems, improve and promote activities concerning occupational health, safety.

• Provide a Safety Procedure for reference and train employees on this procedure. The procedure will be consistent with the details of various machines and equipment being installed in the Power Plant and the laws on occupation health and safety. Provide work safety training to all new employees.

• Provide sufficient number of personal protective equipment (PPE) appropriate to the working condition to all employees.

• Provide a first-aid unit, basic medication, and transporting vehicle in case of emergency in the construction area in accordance with Ministry of Labour's Notification re: Provision for Welfare in the Business Premises, B.E.2548.

• Specify the type and quantity of safety equipment to comply with the standard. Inspect the conditions of the equipment regularly.

• Provide backup electrical system in case of emergency. Design safe and adequate lighting for working.

- Provide pre-employment physical checkup and annual physical checkup.
- Organize a Safety Week to stimulate and train the skills in safe work practice.
- Ensure that the fire prevention system and fire suppression system of the Power

Plant meet the National Fire Protection Association (NFPA) standard and related standards.

• Inspection protective equipment regularly as specified in the Safety Procedure.

• Establish an emergency plan classifying into two levels to be used as guideline in practice in case of emergency (as shown in **Figure 5.1.3.2-1**) as follows:

- Emergency Level One: Emergency Level One is the event occurs in the power plant which the coordinator of emergency can control the situation and limit the damage using the employees, workers and equipment available in the Plant until the event returns to normal.

- Emergency Level Two: Emergency Level Two is the event occurs both inside and outside the power plant which the coordinator of emergency has evaluated the situation that the pre-set plan dealing with Emergency Level One cannot be used and must request for manpower and equipment support from Hemaraj Eastern Seaboard Industrial Estate to control the situation.



Note : The Emergency Plan of Hemaraj Eastern Seaboard Industrial Estate reports change of the details of the project in the Environmental Impact Assessment, Hemaraj Eastern Seaboard Industrial Estate 2nd Edition, 2015.

Figure 5.1.3.2-1 : Emergency Control Chart

• Arrange annual drills of the emergency plan both on the part of the power plant itself and to drill the emergency plan jointly with Hemaraj Eastern Seaboard Industrial Estate and external organizations. Give training to employees at least once a year so that they are equipped with skills and expertise in relieving emergency.

• Appoint a safety officer to organize activities to promote knowledge and understanding about occupational health, safety in conjunction with schools in the vicinity, such as the Chumchon Borisat Namtan Tawan-aok School, at least once a year.

Measures on transportation and unloading of Diesel

Training on the practice according to the emergency plan

- Environmental Health & Safety (EH&S) and the Safety Committee are responsible for training for all employees to possess fundamental knowledge regarding the work rules, the conduct at work and related documents. In the cases of changes of details of the work rules/supporting document involving preparation for emergency, the prevention and suppression of emergency, EH&S must notify all employees of details of the changes.

• Measures to prevent oil leakage.

- Department/Section working with oil must act in accordance with the work method re: Fuel Oil Unloading Procedure.

- Employee working with oil must perform their work carefully in order to prevent spillage outside environment by complying to Fuel Oil Unloading Procedure and related MSDS.

• Prepare/inspect emergency equipment for emergency situation at all time as follow:

- Appropriate PPE such as, rubber gloves, air filtering face mask or other appropriate material for absorption, such as, sand, saw dust, cloth, or other materials with absorbing property or prevention of dispersion of oil for employees working with oil to prevent spillage to outside environment by following Fuel Oil Unloading Procedure and related MSDS.

- Appropriate PPE such as, rubber gloves, mask, air filtering mask and other equipment as deem appropriate.

Containers for waste material contaminated with oil with monthly

inspection of bins, valves, and safety valves every month by competent person as specified by law.

• Emergency equipment in response of oil leakage must be as follows:

- In case of minor oil leakage

> The person encountering the incident must take corrective

action immediately.

> Sprinkle sand, saw dust or other materials prepared by the work unit around the oil leakage to prevent leakage expanding.

> Immediately notify the supervisors and the employee responsible for the area which oil spill occurs to jointly suppress the situation.

> Use scrap cloth or absorbent material to clean up the oil and the area of the oil leakage.

> Collect and discard all the materials used for suppression the leakage in the container prepared for hazardous waste (in accordance with the waste management practice).

> Clean up the area of oil leak thoroughly to prevent any impacts on the environment.

> The supervisor and the employee responsible for the area where the spilling or leakage takes place hold a meeting to find measures to prevent any recurrence.

In case of major oil leakage

> The person encountering the spill or leakage immediately reports it to the supervisor or the employee responsible for the area and relevant persons in order to correct the emergency.

> Fence off the area of large quantity oil spill or leakage to prevent dispersion and for the convenience in correcting and suppressing the emergency.

> The person who tries to control the situation should be

in the direction of upwind in order to avoid the oil vapour and muse wear safety equipment such as, mask to prevent vapor.

> Follow the prevention and response to oil spill or leakage

plan.

Chemical transportation safety measures

Transportation of hazardous chemicals must be operated with utmost emphasis on the safety of communities, assets and environment. Operators of hazardous chemical transportation must fully comply with the project safety procedure, applicable laws and regulations such as Department of Pollution Control Hazardous Materials Transportation Manual of September 2011, Manual on Hazardous Chemicals Management in Workplace, July 2003, and the Notification of Department of Industrial re: Hazardous Chemicals and Storage Manual B.E.2550 such as:

• Chemical transportation operation permit

• Correctly marked chemical transporters as per Department of Land Transport regulations.

- Proper and safe sorting and transportation of chemicals.
- Shipping paper administration

• Material Safety Data Sheet (MSDS) is to be made available for all chemicals being shipped in both Thai and English languages.

• Personal Protective Equipment equipped on board each chemical

• Provide training for drivers of chemical transports, making sure that the drivers understand the hazards of chemicals being shipped. Drivers must also be trained for safe driving skills and emergency mitigation procedures.

Chemical storage safety measures

The Sriracha power plant chemical storage safety measures will comply with the Notification of Department of Industrial Works re: Hazardous Chemicals and Storage Manual (B.E.2550) and the Hazardous Chemicals Management and Administration in Work Places Manual, April 2011 such as:

• Material Safety Data Sheet (MSDS) is to be made available for all chemicals being stored in both Thai and English languages.

• Hazardous substances must be stored and handled as appropriate to the 4 types according to the degree of hazard as follows: type 1 – business operator to comply with specified criteria and procedures, type 2 – as with type 1 and must obtain registration certificate from the authority, type 3 – as with type 2 and obtain permit, and type 4 – prohibited from production, distribution or possession.

transport.

• Hazardous chemical storage must be of in a safe condition or suitable to hazardous chemicals being stored.

Safety Measures for Use of Chemicals

The project will devise chemicals safety measures as per US Occupational Safety and Health Agency (OSHA) and Ministerial Regulations re: Management, Administration, and Implementation of Occupational Health and Safety in Hazardous Chemicals Working Environment (B.E. 2556). Details of the safety measures will also be included in the project safety procedure.

• Prepare Material Safety Data Sheet (MSDS) about the hazard characteristics of the substance's property in Thai and English and place it at the point of work.

• Install warning/ instructional/ caution signs for hazardous chemicals work in clear view at the work area.

• Allocate area and equipment for safety protection in the area of work concerning hazardous substances, such as, the place for eye wash, hand and face wash, and the shower for washing off hazardous substances from body.

• Provide appropriate Personal Protective Equipment to employees working with hazardous chemicals suitable to the nature of the hazard and hazard level to protect employees from possible harm.

• Establish preventive measures for protection against hazardous chemicals at the hazardous chemical storage areas. Preliminary mitigation measures include proper ventilation system, fire prevention system, spill retention dike to prevent chemical leaking out of the hazardous substance storage area and dedicated spill drainages unconnected to water drainage system.

• Provide a hazardous chemical detection equipment to monitor traces of chemicals in the atmosphere of work places and chemical storage areas. An alarm would go off when these chemical traces exceed safe limit.

• Conduct regular monitoring and analyses of chemicals in the atmosphere of work places and hazardous chemical storage areas.

• Provide appropriate fire extinguishers and emergency medical supplies.

• Assign responsibility for chemists to improve chemical administration safety plan.

• Chemists and safety officer shall audit and devise hazardous chemical audit system in each work area requiring use of chemicals with annual review and revision.

• Provide training for all employees who work with chemicals on

safe handling of chemicals, preventive measures and leak detection.
5.1.4 MAJOR HAZARD ASSESSMENT

5.1.4.1 Introducttion

The electricity generating process of the project uses natural gas as main fuel and diesel oil as backup fuel, and also uses chemical in water treatment process. They might cause impacts in case of leakage to environment because of their toxic, flammable or explosive properties. Factors indicating level of danger of the fuel and chemical leakage include properties, quantity, storage places and storage conditions of fuel and chemical. In addition, machine/equipment failure might also damage life and properties in surrounding areas.

Based on situations mentioned above, it is necessary to design, manage, control and operate the power plant concisely and appropriately in order to reduce probability of accidents or severe dangers to staff, communities or properties. Thus, major hazard assessment is necessary to identify tendency of danger severity so that prevention of severe danger in the step of design and operation control, as well as installation of safety equipment in compliance to international standards are implemented.

5.1.4.2 Methodology

Study on major hazard assessment employs guidelines from related agencies, such as World Bank and American Petroleum Institute (API). Scope and methodology of the study are illustrated in **Figure 5.1.4.2-1**.

5.1.4.3 Hazardous substances, Equipment and Machinery Used in the Project5.1.4.3.1 Natural Gas (Main Fuel)

Electricity generating system of the project is designed to enable the use natural gas as main fuel which is transported by natural gas pipeline connected to the pipe of PTT Public Company Limited (PTT) and entry to the project via a metering and regulating station (MRS) located in the project area. In case of full load capacity of 2,500 MW, it is estimated that natural gas consumption rate will be 134,320 Mft³/yr. Natural gas referring to Material Safety Data Sheet (MSDS) from PTT Public Company Limited has low molecular weight, low density, lighter weight than air, and Lower-Upper Flammable Limit value (LFL-UFL) between 5.0-15.0 %. The components of natural gas of the project mainly comprises methane (CH₄) about 87.60-89.33 % by volume.



FIGURE 5.1.4.2-1: CHART OF SCOPE AND PROCEDURE FOR RISK ASSESSMENT

5.1.4.3.2 Diesel Oil (Backup Fuel)

The project maximum diesel oil consumption is 8,500 m³/day in case of trouble with natural gas transportation or command of Electricity Generating Authority of Thailand. The project plans to use 25,500 m³ volume of reserved diesel oil for power plant operation 72 hr in one year. The project plans to store 26,000 m³ volume of reserved diesel oil in 2 tanks, with 14,300 m³ capacity each.

5.1.4.3.3 Chemical Substances

The chemical substances to be used in the process of Sriracha Power Plant is the chemical substances for water treatment, anti scale in water pipes. With reference to Material Safety Data Sheet (MSDS) as shown in **Appendix 3D**, none of the chemicals mentioned above are toxic substances.

5.1.4.3.4 Electric Equipment and Machinery

All electric equipment and machinery are to be designed and tested in compliance with international product standards (**Table 5.1.4.3-1**) or those equivalent according to Thailand's applicable regulations. Four sets of gas turbine generators (GTG) are to be installed. The kinetic energy driving the turbines which in turn powers the electricity generators is to be derived from the thermal energy produced by natural gas burning. The exhaust gas from the GTG is to be transmitted to the heat recovery steam generator (HRSG) to produce the steam used in driving the turbines of the four sets of steam turbine generators (STG).

TABLE 5.1.4.3-1

STANDARDS APPLIED FOR DESIGNS OF ELECTRICAL APPLIANCES AND MACHINERY

ANSI	American National Standard Institute
ASME	American Standard of Mechanical Engineers
AWS	American Welding Society
ISO	International Organization for Standardization
ASA	American Standard Association
IEC	International Electrochemical Commission
NEC	American National Electrical Code
API	American Petroleum Institute
IEEE	American Institute of Electric and Electronics Engineers
NFPA	American National fire Protection Association
JIS	Japanese Industrial Standards

Source : Gulf SRC Co., Ltd, 2015

5.1.4.4 Hazard Identification

Hazard identification will employ method and technique proposed by World Bank and American Petroleum Institute (API) in the Techniques for Assessing Industrial Hazards a Manual (1990), and Base Resources Document (API Publication 581) (2000). The consultant considers probability of occurrence of major hazard for fuel/chemical substances used in the project and the main electrical equipment/machinery within the project. The details of hazard identification are as follows.

5.1.4.4.1 Fuel/Chemical Substances

The main fuel to be used in generating electricity in the project is natural gas, with diesel as reserved fuel. For chemical substances, most of which are to be used in water quality enhancement, of which the amount to be stored will be relatively small. The chemical substance to be stored in the largest amount is 25 % liquid ammonia used to control the nitrogen oxide in the exhaust gas emitted from the combustion in the GTG. The following factors are to be put into consideration in the hazard assessment.

(1) The location where there is probability that the natural gas/diesel/ liquid ammonia may be accidentally released : for example the points of connection in various areas easily accessible to the personnel.

(2) The nature of the accidental release : which is of two types – instantaneous release and continuous release.

(3) The nature of the hazard occurring after the accidental release: whether it is flammable or non-flammable.

(3.1) Ignition : which is of two types – immediate ignition or delayed ignition.

(a) Fire : which in general can takes four different forms

Pool Fire : which occurs when there is a leak in the storage container or accidental release of a flammable material, resulting in its spreading over the area. The extent of the fire depends on the surface area of the fuel.

Jet Fire : which occurs when a flammable agent is ignited after its release from a pressurized, leaked container or pipe. The intensity of the fire is determined by the release amount and the capacity of the source. The bigger the amount and the more pressurized the source is, the wider and longer the flames.

Fireballs and Boiling Lquid Expanding Vapor Explosion (BLEVE):

which is caused by the heat radiated from the fire burning in the vicinity of the vessel containing a flammable substance. If the temperature in the vessel rises and in turn causes the pressure inside to increase, it will tear apart. The flammable substance inside will diffuse into the atmosphere causing ignition in the form of big fireballs.

Flash Fire : which occurs when a chemical substance leaks and disperses into the air. The mixture of air and the dispersed flammable substance in the form of vapor cloud results in combustion, but not explosion.

Vapor Cloud Explosion (VCE): which occurs when a chemical substance leaks and disperses into the air. The mixture of air and the dispersed flammable substance in the form of vapor cloud results in combustion and explosion.

(3.2) In case of accidental release without consequent ignition

Natural gas - which is composed of many types of hydrocarbon compound such as methane, ethane, propane, butane, etc, among which methane generally makes up the most. Other possible constituents include carbon dioxide and oxygen.

As a rule, methane, the main constituent in natural gas, is considered non-toxic. Respiratory exposure to methane of high concentration may induce headache and eyesore, which can be healed when the victim gets fresh clean air. Nevertheless, methane is an Asphyxiating substance, as it replaces and in turn reduces oxygen in the air.

Diesel - respiratory exposure to the vapor of which can induce respiratory tract and lung being irritation, coughing, hyperventilation, chest burning pain, headache, nausea, fatigue, agitation, loss of control, depression and in the worst case coma. Prolonged exposure to diesel can induce cancer.

Liquid ammonia – to be stored in four containers with the capacity of 80 m³ each, around which the concrete curb is to be built with a view to preventing the substance dispersing to nearby areas. For other chemical substances used in enhancing water quality, the concrete curb is also to be built for the same purpose.

5.1.4.4.2 Electrical Equipment and Machinery

The main part of which involves the operation of the steam boiler. Possible mishaps in electricity generation include explosion of the steam boiler caused by continuous rise of the pressure inside, malfunction of the control or safety system and devices, for example.

5.1.4.5 Analysis of the Causes of the Mishaps

5.1.4.5.1 Accidental release of natural gas

Three possible causes leading to accidental release in the natural gas transmission system include (1) decomposition of the pipeline (2) use of pipeline materials not to the standards set (3) third-person deed. In the construction period of the project, in accordance with international standards, damage to the pipeline is to be prevented as follows. To protect against decomposition, the surface of the pipeline is to be coated. To enhance the strength, the pipeline is to be coated both inside and outside. In this way, probability of accidental release in natural gas transmission due to decomposition of the pipeline is very low.

5.1.4.5.2 Accidental Release of Diesel

The statistics from the US Onshore Hazardous Liquid Systems reveals the total number of 2,772 incidents resulting from transportation of hazardous liquid between 1993 and 2013. The main causes of such incidents occurring between January 1, 2004 and December 31, 2013 are decomposition of the pipeline and third-person' deed.

5.1.4.6 Major Hazard Assessment in Different Scenarios

5.1.4.6.1 Major hazard assessment in case of accidental release of natural gas/diesel

Impacts from the accidental release and ignition to the surrounding area is investigated by the researcher. The damage incurred due to thermal radiation can be assessed from the amount of the thermal radiation received, which is measured in terms of the energy received per area unit all through the combustion period. For this, BREEZE HAZ mathematical model as developed by the US' Trinity Consultants Inc. is employed.

(1) Assumption of natural gas and diesel fuel leak

Analyses on properties and components of natural gas, which its main component is methane, with low molecular weight of hydrocarbon and lower density than the air, it is found that the leaks will disperse and float to atmosphere quickly. For diesel oil, the leaks will be in form of liquid spreading over the floor with some evaporation at surface of the oil. Thus consideration on leak and flaming of natural gas and diesel oil will take probability of severe hazard into account, as shown in **Figure 5.1.4.6-1** and **Figure 5.1.4.6-2** respectively.

Leak behavior

Two types of leak are used to assess the severity of impact, caused by leak and flaming. They are:

- Instantaneous release is caused by leak through a medium size of hole up. It can be caused by rupture or severely damaged of natural gas pipeline so that there is a chance of immediate ignition.

- Continuous release is the leak based on continuous flow with longer time than that of the instantaneous release. It usually occurs with small holes.

• Leak size

Designation of leak size at pipeline is considered on the guideline, proposed by the API (2000). Four holes size are specified as small, medium, large and pipe rupture, as shown in **Table 5.1.4.6-1**.

• Leak time

For risk assessment of pipeline system, following the suggestion of API, May 2000, consideration is on detecting and isolation systems of natural gas and diesel oil pipeline systems. For the control of the project transport system, there will be detecting system for methane gas and oil vapor at weld point with leak probability. Thus, the detecting and isolation systems of the project are within Class A of the API (2000) requirement.





RNP/ENV/RT5703/P2810/CH5_ADB_part5

Leak size	Leak size diameter (inch)	Value
Small	0 - 1/4	0.635 cm. (1/4 inch)
Medium	1/4 - 2	2.54 cm (1 inch)
Large	2 – 6	10.16 cm. (4 inch)
Rupture	>16	Pipe diameter or maximum within 16 inch

SPECIFICATION OF SIZE OF LEAKAGE HOLE FOLLOWING API GUIDELINE (2000)

Source : Risk Base Inspection, Base Resources Document; API Publication 581, 1st edition, May 2000

The API suggested that for the natural gas pipes equipped with a Class A detection and isolation system, leakage for risk assessment where the hole sizes are 4 inch, 1 inch and 0.25 inch should be in the timeframe of 5 min, 10 min and 20 min, respectively. For leakage in case of pipe rupture, the duration should be 3 min. The review on different sizes of leak found that probability of 1 inch leak is the highest and the worst case (pipe rupture) is considered. Thus, the assessment is considered leakage time of natural gas and oil equal to 10 min and 3 min.

Regarding to leakage of diesel oil tank, its isolation system controlled by staff is categorized in Class B. Therefore, leakage for risk assessment where the hole sizes are 4 inch, 1 inch and 0.25 inch should be in the timeframe of 10 min, 20 min and 30 min, respectively. For leakage in case of pipe rupture, the duration should be 20 min equal to the case of 4 inch leakage hole. The review on different sizes of leak found that probability of 1 inch leak is the highest and the worst case (pipe rupture) is considered. Thus, the assessment is considered leakage time of oil from the tank equal to 20 min and 10 min.

Release Rate

(a) Natural gas transmission pipeline

The main natural gas transmission pipeline, 18 inch in diameter, in the project area starts at the gas metering station and ends at the gas compressors, from which the natural gas will be transmitted to the electricity generating units through the pipelines of 18 inch and 12 inch in diameter. The natural gas transmission pipeline in the Si Racha Power Plant Project is of iron and of two different diameters.

- Natural gas transmission pipeline of 18 inch in diameter, connected from the gas metering station: two pipelines, 125 m long each. The pipelines are designed to be able to withstand the maximum pressure of 50 barg at the temperature of 50 °C.

- Natural gas transmission pipeline of 18 inch in diameter connected from the gas compressors to the relay point, from which two pipelines of 12 inch in diameter are connected to each individual gas turbine. One pipeline is 150 m long (relaying gas to gas turbine number 1 and 2). Another pipeline is 350 m long (relaying gas to gas turbine number 3 and 4). The pipelines are designed to be able to withstand the maximum pressure of 60 barg at the temperature of 150 °C.

- Natural gas transmission pipeline of 12 inch in diameter connected from the relay point where the aforementioned pipeline of 18 inch in diameter is connected to the flow meter, then to each individual gas turbine : four pipelines in total, approximately 130, 220, 130, and 220 m long respectively. The pipelines are designed to be able to withstand the maximum pressure of 60 barg at the temperature of 150 °C.

- Natural gas transmission pipeline of 12 inch in diameter connected from the flow meter through the fuel gas heater to each individual gas turbine : four pipelines in total, approximately 40 m long each. The pipelines are designed to be able to withstand the maximum pressure of 60 barg at the temperature of 360 °C.

The details are presented in **Table 5.1.4.6-2**. When assessing hazards from natural gas release and its consequent ignition at the connection points, only the case where the release rate is higher than those shown is to be taken into consideration.

TABLE 5.1.4.6-2

NATURAL GAS RELEASE RATES IN RELATIONSHIP WITH DIFFERENT SIZES OF

	Poloaso		Release ra	ate (kg/sec	:)		Release qua	antity (kg)	
Leak	duration	P 50	P 60	P 60	P 60	D E0 have	D 60 have	P 60	P 60
size	(min)	barg	barg	barg	barg	F 50 Darg	T 150 9C2/	barg	barg
	(11111)	T 50 °C¹∕	T 150 °C ²	⊤ 150 °C³⁄	T 360 °C⁴∕	1.50 °C."	1 150 °C-	T 150 °C ^{3/}	T 360 °C⁴∕
1 inch	10	2.99	3.12	3.12	2.55	1793.30	1874.43	459.71	562.33
Rupture	3	765.14	799.76	449.86	367.77	137.725.78	143.956.01	66.198.20	80.975.25

LEAKS AND LEVELS OF RELEASE

Remarks : 1/ The pipeline connected from the area of the MRS to the gas compressor is 18 inch in diameter, inside of which the pressure is 50 barg and the temperature is 50 °C.

2/ The pipeline connected from the gas compressor to the relay point is 18 inch in diameter, inside of which the pressure is 60 barg and the temperature is 150 °C.

3/ The pipeline connected from the relay point to the flow meter is 12 inch in diameter, inside of which the pressure is 60 barg and the temperature is 150 °C.

4/ The pipeline connected from the flow meter to the gas turbine is 12 inch in diameter, inside of which the pressure is 60 barg and the temperature is 150 °C.

(b) Diesel transportation pipeline

The diesel transportation pipeline of the project starts at the storage tank, from which diesel is transported to the electricity generation unit. The pipeline directly connected to the storage tank is 12 inch in diameter. The diameter of the pipeline is decreased to 10, 8, 6, and 5 inch along the way to the electricity generation unit. The details are as follows.

- Diesel transportation pipeline of 12 inch in diameter connected from the storage tank to the electricity generation unit. The length of the pipeline from the storage tank to the fuel oil transfer pump is 150 m. The pipeline is designed to be able to withstand the maximum pressure of 4 barg at the temperature of 50 °C.

- Diesel transportation pipeline of 12 inch in diameter connected from the fuel oil transfer pump to each individual gas turbine. The pipeline is approximately 50 m long and is designed to be able to withstand the maximum pressure of 16 barg at the temperature of 50 °C.

- Diesel transportation pipeline of 10 inch in diameter and 140 inch in length, connected from the aforementioned transportation pipeline of 12 inch in diameter, which is further connected to the transportation pipelines of 8 inch (100 m) and that of 6 inch (90, 120, 120, and 210 m in length respectively) to the main fuel oil pump in each individual electricity generation unit. The pipelines are designed to be able to withstand the maximum pressure of 16 barg at the temperature of 50 °C.

The details are presented in **Table 5.1.4.6-3**. When assessing hazards from diesel oil release and its consequent ignition at the connection points, only the case where the release rate is higher than those shown is to be taken into consideration.

(c) Diesel storage tank

Diesel is to be reserved in the project to the amount of 26,000 m³ in two tanks of 14,300 m³, 37 m in diameter and 14 m high. The release rate and quantity of oil is considered at atmosphere condition as shown in **Table 5.1.4.6-4**.

• Meteorological factors

Meteorological condition is a factor influencing the nature of toxic substance dispersion from its origin to the affected person. How severe the incident is also depends on meteorological factors. According to the Guidance on the Application of Refined Dispersion Models for Hazardous/Toxic Air Releases US.EPA (1993), the meteorological factors affecting and involving dispersion of toxic substance include the wind speed, atmospheric stability, temperature, relative humidity, and air pressure. In the risk analysis of major hazards caused by accidental release and consequent ignition in the project's gas transmission pipeline, meteorological data covering 30 yr from 1985 to 2014 were collected (The Meteorological Department, 2015) from Laem Chabang Weather Watch Station, as this is the station nearest to the project location. The details are as follows.

- wind speed 7.3 knot
- atmospheric stability F
- temperature 28.8 °C
- relative humidity 72.8 %
- air pressure 1009.4 Hecto Pascal

Anticipated Environmental Impacts and Mitigations

Chapter 5

DIESEL RELEASE RATES IN RELATIONSHIP WITH DIFFERENT SIZES OF LEAKS AND LEVELS OF RELEASE											
		Release rate (kg/sec)				Release quantity (kg)					
	Release	P 4 barg	P 16	P 16	P 16	P 16	P 4 barg	P 16 barg	P 16 barg	P 16 barg	P 16 barg
Leak size	duration	Т 50	barg	barg	barg	barg	T 50 °C ^{1/}	T 50 °C ^{2/}	T 50 °C ^{3/}	T 50 °C4/	T 50 ℃5⁄
	(min)	°C1/	Т 50	Т 50	Т 50	Т 50					
			°C ^{2/}	°C3/	°C4/	°C ^{5/}					
1 inch	10	4.82	4.82	4.824	4.824	4.824	2,894.56	2894.56	2894.56	2894.56	2894.56
Rupture	3	694.69	694.69	694.69	308.75	173.67	125,044.89	125,044.89	86,836.73	55,575.51	31,261.22

TABLE 5.1.4.6-3

Remarks: 1/ The pipeline connected from the diesel storage tank to the electricity generation unit is 12 inch in diameter, inside of which the pressure is 4 barg and the temperature is 50 °C.

2/ The pipeline connected from the fuel oil transfer pump through the relay point to each gas turbine is 12 inch in diameter, inside of which the pressure is 16 barg and the temperature is 50 °C.

3/ For the diesel transportation pipeline of 12 inch in diameter, the pressure inside is 16 barg and the temperature is 50 °C.

4/ For the diesel transportation pipeline of 8 inch in diameter, the pressure inside is 16 barg and the temperature is 50 °C.

5/ For the diesel transportation pipeline of 6 inch in diameter, the pressure inside is 16 barg and the temperature is 50 °C.

DIESEL RELEASE RATES IN RELATIONSHIP WITH DIFFERENT SIZES OF LEAKS

Look size (in)	Release duration	Release rate	Release quantity
	(min)	(kg/sec)	(kg)
1	20	8.798	10,557.85
Rupture	10	1,239.005	760,164.91

AND LEVELS OF RELEASE

• Analysis of areas at risk

- Natural gas transmission pipeline system

Risk of severe hazard happening in the natural gas transmission pipeline system can be assessed with reference to the statistics on natural gas transmission pipeline incident, both inside and outside the country, for example those in the USA by referring to the data from the American Petroleum Institute (API). The findings reveal very low chance of accidental natural gas release hazard. Nevertheless, in this study the areas where accidental release of natural gas is possible are assessed. These mainly involve the connection points and areas where third persons can easily access to perform activities such as around the gas compressors and gas turbines.

- Oil transportation pipeline system

Risk of severe hazard happening in the oil transportation pipeline system can be assessed with reference to the statistics on oil transportation pipeline incident, both inside and outside the country, for example those in the USA by referring to the data from the American Petroleum Institute (API). The findings reveal very low chance of oil accidental release hazard. Nevertheless, in this study the areas where oil accidental release is possible are assessed. These mainly involve the connection points such as the points where the oil tanks or oil pumps are connected, the relay points where oil is relayed to each individual gas turbine, and the points where pipelines of different diameter sizes are connected.

Diesel storage tanks

The areas where diesel accidental release is possible are mainly the points where the storage tanks are connected.

(2) Risk Assessment

According to API's assessment of risk to major hazards, two factors are put into consideration – probability or frequency of the incident and level of severity of the incident with respect to the impact incurred. The matrix table is used in the risk assessment with the Y axis representing the frequency of the incident and the X axis representing the level of severity, as shown in **Figure 5.1.4.6-3**. The details are as follows.



FIGURE 5.1.4.6-3: ACCIDENT FREQUENCY/SEVERITY SCREENING MATRIX

• Probability or frequency of the incident : the assessment is based on the criteria in the Handbook of Chemical Hazard Analysis Procedures (1990) developed by the Federal Emergency Management Agency, U.S. Department of Transportation, U.S.EPA. The details are shown in **Table 5.1.4.6-5**.

• Severity level of the incident : the assessment is based on the criteria in the Handbook of Chemical Hazard Analysis Procedures (1990) developed by the Federal Emergency Management Agency, U.S. Department of Transportation, U.S.EPA. The details are shown in **Table 5.1.4.6-6**.

The impact from the accidental release and combustion results from the thermal energy incurred, which is measured in terms of the amount of energy incurred per area unit, as shown in **Table 5.1.4.6-7**. For the impacts from the explosion at different pressure levels, the details are shown in **Table 5.1.4.6-8**.

DEFINITION OF PROBABILITY LEVEL OF MAJOR HAZARD

Probability Level	Definition
Common	Likely to occur 1 times/yr or more (>1 times/yr)
Likely	Likely to occur 1 times in 10 yr (>0.1 times/yr)
Reasonably likely	Likely to occur 1 times in 10-100 yr (0.1 to 1×10^{-2} times/yr)
Unlikely	Likely to occur 1 times in 100-1,000 yr (1 \times 10 ⁻² to 1 \times 10 ⁻³ times/yr)
Very Unlikely	Likely to occur 1 times in 1,000 yr (<1×10 ⁻³ times/yr)

Source : Handbook of Chemical Hazard Analysis Procedures, Federal Emergency Management Agency, U.S. Department of Transportation, US.EPA, 1990.

TABLE 5.1.4.6-6

SEVERITY LEVEL OF MISHAP

Severity	Definition
Minor	- Small number of injured persons
	- No need to move out from the area
	- Small contamination in environment, no need to treat
Moderate	- Less than 10 deaths and less than 100 injured persons
	- Less than 2,000 people need to be moved out.
	- Contamination in environment that needs to be treated.
Major	- Less than 100 deaths and several hundreds of injured persons
	- Less than 20,000 people need to be moved out.
	- Contamination in environment that needs to be proper treated.
Catastrophic	- More than 100 deaths and more than 300 injured persons
	- More than 20,000 people need to be moved out.
	- Contamination in environment that needs to be proper treated, with
	long period.

Source : Handbook of Chemical Hazard Analysis Procedures, Federal Emergency Management Agency, U.S. Department of Transportation, 1990.

Heat energy	Type and size of impact			
level (kW/m²)	Impact on devices	Impact on human		
37.5	Destroy equipments in the	- 100 % death if present in the area for 1 min and 1		
	manufacturing process	% death if present in the area for 10 sec		
25.0	Burning of wooden structures	- 100 % death if present in the area for 1 min and		
	without flame	severely injured within 10 sec		
12.5	Burning of wooden structures	- 1 % death if present in the area for 1 min		
	with flame and melting of	and skin burnt within 10 sec		
	plastics			
4.0	-	 Skin irritation if present in the area for longer than 		
		20 sec but no swelling		
1.6	-	 Causing abnormality to a body if exposure for long 		
		period		

IMPACTS OF FLAMING AT VARIOUS LEVELS OF HEAT ENERGY

Source : World Bank Technical Paper No.35, 1988

TABLE 5.1.4.6-8

IMPACT OF EXPLOSION AT VARIOUS LEVELS OF PRESSURE

Presure (psig)	Impact
0.345	1-99 % of human directly exposing to pressure will die
0.138	Nearby constructions and equipment are completely destroyed.
0.069	Nearby constructions and equipment are severe damaged.
0.039	Glasses shake and partly break, but can be fixed.

Source : Lees, Frank P., Loss Prevention in the Process Industries, Vol. 1. London and Boston (1980)

(2.1) Probability of Risk

(a) Probability of pipeline/tank leakage

Probability of risk of leakage in the natural gas/diesel pipelines and diesel storage tanks is assessed with reference to the statistics on the frequency of related incidents as collected by the API and published in the Risk Based Inspection, Base Resource Documents; API Publication 581 (2000). The details are shown in **Table 5.1.4.6-9**

With respect to probability of incident occurring at the points where the natural gas/diesel pipelines and diesel storage tanks are connected and in accordance with Table 5.1.4.6.9, probability of incident involving the 1-inch leak is the highest. The consultant; therefore, chooses to assess probability of incident involving the 1inch leak and the worst case scenario of rupture, the details of which are as follows.

FREQUENCY OF MISHAPS OF EQUIPMENT AND VARIOUS SIZES OF

Equipment	Frequency of Leakage (times/yr/ft)					
Equipment	Hole size 0.25 inch	Hole size 1 inch	Hole size 4 inch	Rupture		
Piping, 1.905 cm. (0.75 inch) diameter, per ft	1×10 ⁻⁵	-	-	3×10 ⁻⁷		
Piping, 2.54 cm. (1 inch) diameter, per ft	5×10 ⁻⁶	-	-	5×10 ⁻⁷		
Piping, 5.08 cm. (2 inch) diameter, per ft	3×10 ⁻⁶	-	-	6×10 ⁻⁷		
Piping, 10.16 cm. (4 inch) diameter, per ft	9×10 ⁻⁷	6×10 ⁻⁷	-	7×10 ⁻⁸		
Piping, 15.24 cm. (6 inch) diameter, per ft	4×10 ⁻⁷	4×10 ⁻⁷	-	8×10 ⁻⁸		
Piping, 20.32 cm. (8 inch) diameter, per ft	3×10 ⁻⁷	3×10 ⁻⁷	8×10 ⁻⁸	2×10 ⁻⁸		
Piping, 25.40 cm. (10 inch) diameter, per ft	2×10 ⁻⁷	3×10 ⁻⁷	8×10 ⁻⁸	2×10 ⁻⁸		
Piping, 30.48 cm. (12 inch) diameter, per ft	1×10 ⁻⁷	3×10 ⁻⁷	3×10 ⁻⁸	2×10 ⁻⁸		
Piping, 40.64 cm. (16 inch) diameter, per ft	1×10 ⁻⁷	3×10 ⁻⁷	2×10 ⁻⁸	2×10 ⁻⁸		
Piping, >40.64 cm. (16 inch) diameter, per ft	6×10 ⁻⁸	2×10 ⁻⁷	2×10 ⁻⁸	1×10 ⁻⁸		
Atmospheric Storage Tank	4×10 ⁻⁵	1×10 ⁻⁴	1×10 ⁻⁵	2×10 ⁻⁵		

PIPELINE SUGGESTED BY API

Source : Risk Based Inspection, Base Resource Documents; API Publication 581, 2000

(a.1) Natural gas transmission pipeline

• The pipeline connected from the area of the MRS to that of

the gas compressor - 18 inch in diameter, 125 m in length

In the case of leak of 1 inch

Probability of incident =
$$2 \times 10^{-7}$$
 times/yr/ft $\times \frac{3,280.84 \text{ ft}}{1 \text{ km}} \times 0.125 \text{ km}$
= 8.20×10^{-5} times/yr

In the case of rupture

Probability of incident =
$$1 \times 10^{-8}$$
 times/yr/ft $\times \frac{3,280.84 \text{ ft}}{1 \text{ km}} \times 0.125 \text{ km}$
= 4.10×10^{-6} times/yr

• The pipeline connected from gas compressure to relay point

to 12-inch piprline - 18 inch in diameter, 125 and 350 m in length

In the case of leak of 1 inch (Length 125 m)

Probability of incident =
$$2 \times 10^{-7}$$
 times/yr/ft $\times \frac{3,280.84 \text{ft}}{1 \text{ km}} \times 0.125 \text{ km}$
= 8.20×10^{-5} times/yr

In the case of leak of 1 inch (Length 350 m) Probability of incident = 2×10^{-7} times/yr/ft × $\frac{3,280.84 \text{ft}}{2}$ – × 0.35 km 1 km 2.30×10⁻⁴ times/yr In the case of rupture (Length 125 m) Probability of incident = 1×10^{-8} times/yr/ft $\times \frac{3,280.84 \text{ ft}}{-----}$ ——— ×0.125 km 1 km $= 4.10 \times 10^{-6}$ times/yr In the case of rupture (Length 350 m) Probability of incident = 1×10^{-8} times/yr/ft $\times \frac{3,280.84 \text{ ft}}{\dots} \times 0.350 \text{ km}$ 1 km $= 1.15 \times 10^{-5}$ times/yr The pipeline connected from relay point of 18-inch pipeline to flow meter – 12 inch in diameter, 130, 220, 130 and 220 m in length In the case of leak of 1 inch (Length 130 m) 1 km $= 1.28 \times 10^{-4}$ times/yr In the case of leak of 1 inch (Length 220 m) Probability of incident = 3×10^{-7} times/yr/ft $\times \frac{3,280.84 \text{ ft}}{2000} \times 0.220 \text{ km}$ 1 km $= 2.17 \times 10^{-4} \text{ times/yr}$ In the case of rupture (Length 130 m) Probability of incident = 2×10^{-8} times/yr/ft× $\frac{3,280.84 \text{ ft}}{-----}$ – ×0.130 km 1 km $= 8.53 \times 10^{-6}$ times/yr In the case of rupture (Length 220 m) Probability of incident = 2×10^{-8} times/yr/ft $\times \frac{3,280.84 \text{ ft}}{2}$ –×0.220 km 1 km $= 1.44 \times 10^{-5}$ times/yr The pipeline connected from the flow meter to gas turbine -12 inch in diameter, 40 m in length In the case of leak of 1 inch Probability of incident = 3×10^{-7} times/yr/ft $\times \frac{3,280.84 \text{ ft}}{3,280.84 \text{ ft}}$ —×0.040 km 1 km $= 3.94 \times 10^{-5}$ times/vr In the case of rupture Probability of incident = 2×10^{-8} times/yr/ft $\times \frac{3,280.84 \text{ ft}}{2000 \text{ km}} \times 0.040 \text{ km}$ 1 km $= 2.62 \times 10^{-6}$ times/yr

In addition, with reference to the record of leakage of natural gas transmission pipeline system in Thailand, particularly the onshore pipeline of 1,940 km long, in 34 yr (PTT Plc., 2015), the frequency of incidents is 12 times/ (34 yr x 1,940 km), which equals 1.82×10^{-4} times/yr/km (or equivalent to 5.55×10^{-8} times/yr/ft). When this is used in assessing the probability of incident which can occur to the natural gas transmission pipeline in the project, the results are as shown in **Table 5.1.4.6-10**. When the PTT's record of leakage of natural gas transmission pipeline of every size in 34 yr is put in comparison with the statistics on probability of incident as collected by API, the probably is lower. As API is an organization internationally acclaimed for its reliable sources of data on petroleum transportation through pipeline, its data on accidental release probability are referred to in the project's risk assessment.

TABLE 5.1.4.6-10

COMPARISON OF PROBABILITY OF MISHAPS IN NATURAL GAS PIPELINE FROM PTT DURING 34 YR OF OPERATION AND FROM API DATA

leak size	Frequency of misha (times/)	aps in gas pipeline yr/km)	Probability of mishaps in gas pipeline (times/yr)		
	API ^{1/}	PTT ^{2/}	API	PTT	
18-inch pipe	line with 125 m in ler	ngth			
1 inch	9.84×10 ⁻⁴	4.55×10 ⁻⁵	8.20×10 ⁻⁵	5.69×10 ⁻⁶	
Rupture	6.56×10 ⁻⁵	-	4.10×10 ⁻⁶	-	
18-inch pipeline with 350 m in length					
1 inch	9.84×10 ⁻⁴	4.55×10⁻⁵	2.30×10 ⁻⁴	1.59×10 ⁻⁵	
Rupture	6.56×10 ⁻⁵	-	1.15×10 ⁻⁵	-	
12-inch pipe	line with 130 m in ler	ngth			
1 inch	9.84×10 ⁻⁴	4.55×10⁻⁵	1.28×10 ⁻⁴	5.92×10 ⁻⁶	
Rupture	6.56×10 ⁻⁵	-	8.53×10 ⁻⁶	-	
12-inch pipe	line with 220 m in ler	ngth			
1 inch	9.84×10 ⁻⁴	4.55×10⁻⁵	2.17×10 ⁻⁴	2.07×10 ⁻⁴	
Rupture	6.56×10 ⁻⁵	-	1.44×10 ⁻⁵	-	
12-inch pipe	line with 40 m in leng	gth			
1 inch	9.84×10 ⁻⁴	4.55×10 ⁻⁵	3.94×10 ⁻⁵	1.82×10 ⁻⁶	
Rupture	6.56×10 ⁻⁵	-	2.62×10 ⁻⁶	-	
Perset , ^{1/} Probability of michans in patural gas pipeline assorting to pipe diameter as data of					

Remark : ^{1/} Probability of mishaps in natural gas pipeline according to pipe diameter as data of API (Table 5.1.4.6-9)

Probability of mishaps in natural gas pipeline accounted on all sizes of pipe diameter as operation by PTT Public Co., Ltd. (No pipe rupture was found) (a.2) Diesel transportation pipeline

• The pipeline connected from the area of the diesel storage

tank to the electricity generation units - 12 inch in diameter, 150 m in length

In the case of leak of 1 inch

Probability of incident =
$$3 \times 10^{-7}$$
 times/yr/ftx $\frac{3,280.84 \text{ ft}}{1 \text{ km}} \times 0.150 \text{ km}$
= 1.48×10^{-4} times/yr

In the case of rupture

Probability of incident =
$$2 \times 10^{-8}$$
 times/yr/ft $\times \frac{3,280.84 \text{ft}}{1 \text{ km}} \times 0.150 \text{ km}$
= 9.84×10^{-6} times/yr

• The pipeline connected from the fuel oil transfer pump to

the relay point to each gas turbine - 12 inch in diameter, 50 m in length

In the case of leak of 1 inch

Probability of incident =
$$3 \times 10^{-7}$$
 times/yr/ft $\times \frac{3,280.84 \text{ft}}{1 \text{ km}} \times 0.050 \text{ km}$
= 4.92×10^{-5} times/yr

In the case of rupture

Probability of incident =
$$2 \times 10^{-8}$$
 times/yr/ft $\times \frac{3,280.84 \text{ ft}}{1 \text{ km}} \times 0.050 \text{ km}$
= 3.28×10^{-6} times/yr

• The 10-inch pipeline with 140 m in length

In the case of leak of 1 inch

Probability of incident =
$$3 \times 10^{-7}$$
 times/yr/ft $\times \frac{3,280.84 \text{ ft}}{1 \text{ km}} \times 0.140 \text{ km}$
= 1.38×10^{-4} times/yr

In the case of rupture

Probability of incident =
$$2 \times 10^{-8}$$
 times/yr/ft $\times \frac{3,280.84 \text{ ft}}{1 \text{ km}} \times 0.140 \text{ km}$
= 9.19×10^{-6} times/yr

• The 8-inch pipeline with 100 m in length

In the case of leak of 1 inch

Probability of incident =
$$3 \times 10^{-7}$$
 times/yr/ft $\times \frac{3,280.84 \text{ ft}}{1 \text{ km}} \times 0.100 \text{ km}$
= 9.84×10^{-5} times/yr

In the case of rupture Probability of incident = 2×10^{-8} times/yr/ft $\times \frac{3,280.84 \text{ ft}}{1 \text{ km}} \times 0.100 \text{ km}$ $= 6.56 \times 10^{-6} \text{ times/yr}$ The 6-inch pipeline with 90, 120, 120 and 210 m in length • In the case of leak of 1 inch (Length 90 m) Probability of incident = 4×10^{-7} times/yr/ft $\times \frac{3,280.84 \text{ ft}}{1 \text{ km}} \times 0.090 \text{ km}$ = 1.18×10⁻⁴ times/yr In the case of leak of 1 inch (Length 120 m) Probability of incident = 4×10^{-7} times/yr/ft $\times \frac{3,280.84 \text{ft}}{1 \text{ km}} \times 0.120 \text{ km}$ $= 1.57 \times 10^{-4}$ times/yr In the case of leak of 1 inch (Length 210 m) Probability of incident = 4×10^{-7} times/yr/ft $\times \frac{3,280.84 \text{ ft}}{1 \text{ km}} \times 0.210 \text{ km}$ $= 2.76 \times 10^{-4}$ times/yr In the case of rupture (Length 90 m) Probability of incident = 8×10^{-8} times/yr/ft $\times \frac{3,280.84 \text{ ft}}{3,280.84 \text{ ft}} \times 0.090 \text{ km}$ $= 2.36 \times 10^{-5}$ times/yr In the case of rupture (Length 120 m) Probability of incident = 8×10^{-8} times/yr/ft $\times \frac{3,280.84 \text{ ft}}{10^{-8}} \times 0.12 \text{ km}$ $= 3.15 \times 10^{-5}$ times/yr In the case of rupture (Length 210 m) Probability of incident = 8×10^{-8} times/yr/ft $\times \frac{3,280.84 \text{ ft}}{1 \text{ km}} \times 0.210 \text{ km}$ $= 5.51 \times 10^{-5}$ times/yr In addition, with reference to the record of accidental release of oil transportation pipeline system in Thailand from 1994 to December 2014 (21 yr),

approximately 429 km long in total (Thai Petroleum Pipeline Co., Ltd.'s pipeline of approximately 360 km in length and Fuel Pipeline Translation Co., Ltd.'s pipeline of approximately 69 km in length), one incident occurred under the administration of Thai

Petroleum Pipeline Co., Ltd. (THAPPLINE) involving a leak of approximately 3-4 mm in diameter. The probability of incident is thus equal to 1.11×10^{-4} times/yr/km. When this is used in assessing the probability of incident which can occur to the oil transportation pipeline in the project, the results are as shown in Table 5.1.4.6-11. When Thai Petroleum Pipeline Co., Ltd's record of accidental release of oil transportation pipeline in 21 yr is put in comparison with the statistics on probability of incident as collected by API, the probably is lower. As API is an organization internationally acclaimed for its reliable sources of data on petroleum transportation through pipeline, its data on accidental release probability are referred to in the project's risk assessment.

TABLE 5.1.4.6-11

COMPARISON OF PROBABILITY OF MISHAPS IN OIL PIPELINE FROM THAI PETROLEUM PIPELINE CO., LTD. (THAPPLINE) DURING 21 YR OF OPERATION AND FROM API DATA

Leak size	Frequency of misha (times/y	ps in gas pipeline /r/km)	Probability of mishaps in gas pipeline (times/yr)		
	ΔΡΙ ^{1/}	THAPPI INF ^{2/}			
12-inch nineli	ne with 150 m in length				
1 inch	9 84×10 ⁻⁴	_	1 48×10 ⁻⁴	_	
Rupture	6.56×10 ⁻⁵		9.84×10 ⁻⁶		
12-inch pipeli	ne with 50 m in length		9.017410		
1 inch	9.84×10 ⁻⁴	-	4.92×10 ⁻⁵	-	
Rupture	6.56×10 ⁻⁵	-	3.28×10 ⁻⁶	-	
10-inch pipeline with 140 m in length					
1 inch	9.84×10 ⁻⁴	_	1.38×10 ⁻⁴	-	
Rupture	6.56×10 ⁻⁵	-	9.19×10 ⁻⁶	-	
8-inch pipelin	e with 100 m in length		· · · · ·		
1 inch	9.84×10 ⁻⁴	-	9.84×10 ⁻⁵	-	
Rupture	6.56×10 ⁻⁵	-	6.56×10 ⁻⁶	-	
6-inch pipelin	e with 90 m in length				
1 inch	9.84×10 ⁻⁴	-	1.18×10 ⁻⁴	-	
Rupture	6.56×10 ⁻⁵	-	2.36×10 ⁻⁵	-	
6-inch pipelin	e with 120 m in length				
1 inch	9.84×10 ⁻⁴	-	1.57×10 ⁻⁴	-	
Rupture	6.56×10 ⁻⁵	-	3.15×10 ⁻⁵	-	
6-inch pipelin	e with 210 m in length				
1 inch	9.84×10 ⁻⁴	-	2.76×10 ⁻⁴	-	
Rupture	6.56×10 ⁻⁵	-	5.51×10 ⁻⁵	-	
Remark \cdot ^{1/} Prohability of mishans in oil nineline according to nine diameter as data of API (Table 5.5.6-9)					

Probability of mishaps in oil pipeline according to pipe diameter as data of API (Table 5.5.6-9)

Probability of mishaps in oil pipeline accounted on all sizes of pipe diameter as operation by Thai Petroleum Pipeline Co., Ltd. (No leak of 1 inch and pipe rupture were found)

2/

(a.3) Diesel storage tank

In the case of leak of 1 inch

Assessment in the case there is leak of 1 inch at the atmospheric storage tank, the probability of incident is 1×10^{-4} times/yr.

In the case of rupture

Assessment in the case there is breakage in the area of the flange or pipe fitting, with the size of the leak assessed in regard to the size of the largest pipe fitting, i.e. 12 inch, probability of incident is 2×10^{-5} times/yr.

Regarding accidental release probability of the storage tank with reference to API's data, as shown in **Table 5.5.6-9**, in the case of the leak of 1 inch, the probability of incident is 1×10^{-4} times/yr. In the case of rupture, the probability of incident is 7×10^{-8} times/yr. As there are no statistical data on accidental release from the storage tank in Thailand available, the accidental release probability of the storage tank is assessed with reference to API's data thereon.

(b) probability of natural gas/diesel ignition

According to Risk Based Inspection, Base Resource Documents; API Publication 581 (2000), the probability of incident caused by either sudden or prolonged accidental release of substances in the form of gas (natural gas) and liquid (diesel), and probability of different incidents occurred in the condition below the auto-ignition temperature are as shown in Table 5.1.4.6-12 and Table 5.1.4.6-13.

Leakage	Probability of incident		Probability of leak and ignition					
	No	Ignition	Vapor Cloud	Fireball	Flash	lot Eiro	Pool Fire	
	Ignition	ignition	Explosion (VCE)	FILEDall	Fire	Jet File		
Immediate	0.8	0.2	0.04	0.01	0.15	-	-	
Contiinue	0.8	0.2	0.04	-	0.06	0.1	-	

TABLE 5.1.4.6-12

PROBABILITY OF INCIDENT OF GAS (C1-C2)

Source : Risk Based Inspection, Base Resource Documents; API Publication 581, 2000

TABLE 5.1.4.6-13

PROBABILITY OF INCIDENT OF LIQUID (C9-C16)

	Probability of incident		Probability of leak and ignition					
Leakage	No Ignition	Ignition	Vapor Cloud Explosion (VCE)	Fireball	Flash Fire	Jet Fire	Pool Fire	
Immediate	0.95	0.05	-	-	-	-	0.05	
(Instantaneous Release)								
Contiinue	0.95	0.05	-	-	-	0.01	0.04	
(Continuous Release)								

Source : API, API Publication 581, first edition, May 2000.

In the case of accidental release of natural gas, sudden or prolonged, the probability that the gas can combust is 0.2 or 20 %. In other words, if accidental release of natural gas occurs 100 times, the probability that the gas can combust is 20 times. The natures of combustion probability can be categorized as follows.

- Probability of ignition in the form of fireballs : can occur in the case of sudden release of natural gas in large quantity, which leads to combustion and starts fire in the form of fireballs. The probability is 0.01 or 1 % of the total incidents of accidental release.

- Probability of ignition in the form of flash fire : can occur in the case of both sudden and prolonged accidental release. The probability is 0.15 and 0.06, respectively or 15 % and 6 % respectively of the total incidents of accidental release.

- Probability of ignition in the form of jet fire : can occur only in the case that there are prolonged release of natural gas and consequent combustion. The pressure from the gas inside the pipeline causes flame to spurt from the leak. The probability is 0.1 or 10 % of the total incidents of accidental release.

 Probability of ignition in the form of vapor cloud explosion: can occur in the case of both sudden and prolonged accidental release. The probability is 0.04 or 4 % of the total incidents of accidental release.

In the case of accidental release of diesel, sudden or prolonged, the probability that the diesel can combust is 0.05 or 5 %. In other words, if accidental release of diesel occurs 100 times, the probability that the diesel can combust is 5 times. The natures of fire probability can be categorized as follows.

Probability of ignition in the form of jet fire : can occur only in the case that there are prolonged release of diesel and consequent combustion. The pressure from the vapor inside the pipeline causes flame to spurt from the leak. The probability is 0.01 or 1 % of the total incidents of accidental release.

- Probability of ignition in the form of pool fire : can occur in the case of both sudden and prolonged accidental release. The probability is 0.05 and 0.04 respectively or 5 % and 4 % respectively of the total incidents of accidental release.

(c) Probability of accidental release and ignition of natural gas/diesel, the different cases are as follows:

(c.1) Natural gas transmission pipeline

For the nature of accidental release from gas transmission pipeline system, with reference to **Table 5.1.4.6-12**, the probability of harm caused to property

and life resulting from natural gas combustion is of three different ignition forms – jet fire, fireballs, and VCE. There is probability of accidental release and all aforementioned forms of ignition occurring to the project's natural gas transmission pipeline, both that of 12 inch and 18 inch in diameter. This mostly involves leaks of small size (1 inch), and prolonged mode of accidental release. The ignition incurred is in the form of jet fire. The probability is 0.10 or 10 % of the total incidents of accidental release. With reference to the levels of likelihood of major hazards set in line with U.S.EPA's guidelines (1990), the details of which are shown in **Table 5.1.4.6-5**; the project's likelihood of major hazards is at the level of 'Very Unlikely', as shown in **Table 5.1.4.6-14**.

However, natural gas, which is lighter than air, can disperse relatively well when compared to other types of gas if accidentally released. In comparison, LPG, for example, is less safe, because it is heavier than air and its dispersion is thus dense and low above the surface. Moreover, the probability of natural gas accumulation to the flammable limits and explosion limits are very low. In this way, probability of accidental release and ignition in the forms of fireballs, and VCE is highly unlikely.

In this study; therefore, only impacts resulting from natural gas accidental release and ignition, which can inflict harm to property and lives, in the form of jet fire, the probability of which is the highest; are investigated.

(c.2) Diesel transportation pipeline and diesel storage tank

• Diesel transportation pipeline

For the nature of accidental release from the diesel transportation pipeline, with reference to **Table 5.5.6-13**, the probability of harm caused to property and life resulting from consequent natural gas and diesel combustion is of two different ignition forms – jet fire, and pool fire. Since the boiling temperature of diesel is between 180-340 °C, there is no probability of ignition in the form of jet fire. As the accidental release of diesel is of prolonged nature resulting in sprays, there is no probability of ignition in the form of pool fire. However, prolonged release of diesel at the storage tank can cause ignition in the form of fireball and VCE. In this study; therefore, impacts resulting from diesel accidental release and combustion, which can inflict harm to property and lives, in the form of fireball and VCE are investigated. With reference to the levels of likelihood of major hazards set in line with U.S.EPA's guidelines (1990), the details of which are shown in Table 5.1.4.6-5; the project's likelihood of severe hazards is at the level of 'Very Unlikely', as shown in Table 5.1.4.6-15.

PROBABILITY OF MAJOR HAZARD OCCURRENCE AROUND THE NATURAL GAS

Pipe diameter/ Leak size		Probability of leakage (times (vr)	Probability of fire (times/yr)	Probability of serious case							
1.	Pipe connection of	of MBS to Gas Com	pressor - 18 inch in diam	eter. 125 m in length							
	Look 1 inch	° 20×10 ⁻⁵	9 20×10 ⁻⁶	Very Unlikely							
	- Leak 1 Inch	8.20×10*	8.20×10	Very Unlikely							
	(Rupture)	4.10×10⁻°	4.10×10 ⁻⁷	very Unukety							
2.	2. Pipe connection of Gas Compressor to relay point to 12-inch pipeline - 18 inch in diameter, 125 m										
	in length										
	- Leak 1 inch	8.20×10 ⁻⁵	8.20×10 ⁻⁶	Very Unlikely							
	– Leak 18 inch	4.10×10 ⁻⁶	4.10×10 ⁻⁷	Very Unlikely							
	(Rupture)										
3.	Pipe connection of Gas Co	ompressor ot relay	point to 12-inch pipeline	- 18 inch in diameter, 350 m							
	in length										
	- Leak 1 inch	2.30×10 ⁻⁴	2.30×10 ⁻⁵	Very Unlikely							
	- Leak 18 inch	1.15×10 ⁻⁵	1.15×10 ⁻⁶	Very Unlikely							
	(Rupture)										
4.	4. Pipe connection of relay point of 18-inch pipeline to flow meter -12 inch in diameter, 130 m in										
	length										
	- Leak 1 inch	1.28×10 ⁻⁴	1.28×10 ⁻⁵	Very Unlikely							
	- Leak 12 inch	8.53×10 ⁻⁶	8.53×10 ⁻⁷	Very Unlikely							
	(Rupture)										
5.	5. Pipe connection of relay point of 18-inch pipeline to flow meter -12 inch in diameter, 220 $ m m$ in										
	length										
	- Leak 1 inch	2.17×10 ⁻⁴	2.17×10 ⁻⁵	Very Unlikely							
	- Leak 12 inch	1.44×10 ⁻⁵	1.44×10 ⁻⁶	Very Unlikely							
	(Rupture)										
6.	6. Pipe connection of flow meter to gas turbine - 12 inch in diameter, 40 m in length										
	- Leak 1 inch	3.94×10 ⁻⁵	3.94×10 ⁻⁶	Very Unlikely							
	- Leak 12 inch	2.62×10 ⁻⁶	2.62×10 ⁻⁷	Very Unlikely							
	(Rupture)										

PIPELINE OF THE PROJECT

Source : Risk Based Inspection, Base Resource Documents; API Publication 581, 2000

• Diesel storage tank

Regarding the nature of accidental release from the diesel storage tank, with reference to **Table 5.1.4.6-13**, the probability of harm caused to property and life resulting from consequent diesel combustion is of two different ignition forms – jet fire, and pool fire. Since the boiling temperature of diesel is between 180-340 °C, there is no probability of ignition in the form of jet fire. As the accidental release of diesel at the point connected to the storage tank is of prolonged nature, the probability of ignition in the form of pool fire is equal to 0.04 or 4 %. Sustained release of diesel at the storage tank can cause ignition in the form of fireball and VCE. In this study; therefore, impacts resulting from diesel accidental release and combustion, which can inflict harm to property and lives, in the form of pool fire, fireballs and VCE are investigated. With reference to the levels of likelihood of major hazards set in line with U.S.EPA's guidelines (1990), the details of which are shown in Table 5.5.6-5; the project's likelihood of severe hazards is at the level of 'Very Unlikely', as shown in Table 5.1.4.6-16.

	Probability of leak	Probability of igr	nition (times/yr)	Probability of major hazard occurrence		
Pipe diameter/ Leak size	(times/yr)	Fireball	VCE	Fireball	VCE	
Pipe connection of diesel	tank to electricity generating ur	nit - 12 inches in diamet	er, 150 m in length			
- Leak 1 inch	1.48×10 ⁻⁴	1.48×10 ⁻⁴	1.48×10 ⁻⁴	Very Unlikely	Very Unlikely	
Leak 12 inches (Rupture)	9.84×10 ⁻⁶	9.84×10 ⁻⁶	9.84×10 ⁻⁶	Very Unlikely	Very Unlikely	
Pipe connection of fuel O	il Transfer Pump to relay point	to gas turbine - 12 inche	es in diameter, 50 m in le	ength		
- Leak 1 inch	4.92×10 ⁻⁵	4.92×10 ⁻⁵	4.92×10 ⁻⁵	Very Unlikely	Very Unlikely	
- Leak 12 inches (Rupture)	3.28×10 ⁻⁶	3.28×10 ⁻⁶	3.28×10 ⁻⁶	Very Unlikely	Very Unlikely	
10-inch Pipe with 140 m i	n length					
- Leak 1 inch	1.38×10 ⁻⁴	1.38×10 ⁻⁴	1.38×10 ⁻⁴	Very Unlikely	Very Unlikely	
- Leak 10 inches (Rupture)	9.19×10 ⁻⁶	9.19×10 ⁻⁶	9.19×10 ⁻⁶	Very Unlikely	Very Unlikely	
8-inch Pipe with 100 m in	length					
- Leak 1 inch	9.84×10 ⁻⁵	9.84×10 ⁻⁵	9.84×10 ⁻⁵	Very Unlikely	Very Unlikely	
- Leak 8 inches (Rupture)	6.56×10 ⁻⁶	6.56×10 ⁻⁶	6.56×10 ⁻⁶	Very Unlikely	Very Unlikely	
6-inch Pipe with 90 m in l	ength				·····•	
– Leak 1 inch	1.18×10 ⁻⁴	1.18×10 ⁻⁴	1.18×10-4	Very Unlikely	Very Unlikely	
- Leak 6 inches (Rupture)	2.36×10 ⁻⁵	2.36×10 ⁻⁵	2.36×10 ⁻⁵	Very Unlikely	Very Unlikely	
6-inch Pipe with 120 m in	length				·····•	
– Leak 1 inch	1.57×10 ⁻⁴	1.57×10 ⁻⁴	1.57×10 ⁻⁴	Very Unlikely	Very Unlikely	
 Leak 6 inches (Rupture) 	3.15×10 ⁻⁵	3.15×10 ⁻⁵	3.15×10 ⁻⁵	Very Unlikely	Very Unlikely	
6-inch Pipe with 210 m in	length				·····•	
– Leak 1 inch	2.76×10 ⁻⁴	2.76×10 ⁻⁴	2.76×10 ⁻⁴	Very Unlikely	Very Unlikely	
- Leak 6 inches (Rupture)	8.00×10 ⁻⁸	8.00×10 ⁻⁸	8.00×10 ⁻⁸	Very Unlikely	Very Unlikely	

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PROBABILITY OF MAJOR HAZARD OCCURRENCE AROUND THE DIESEL STORAGE TANK

	Propabality of leak	Propability of ignition			Propability of major hazard			
Pipe diameter/Leak size		(times/yr)			occurrence			
Pipe diameter/Leak size		Pool	Fire	VCE	Pool	Fire	VCE	
	(times/yr)	Fire	ball		Fire	ball		
At the area of diesel oil storage tank								
- Leak 1 inch	1×10 ⁻⁴	4×10 ⁻⁶	1×10 ⁻⁴	1×10 ⁻⁴	Very	Very	Very	
					Unlikely	Unlikely	Unlikely	
- Leak 12 inches	7×10 ⁻⁸	2.8×10 ⁻⁹	7×10 ⁻⁸	7×10 ⁻⁸	Very	Very	Very	
(Rupture)					Unlikely	Unlikely	Unlikely	

OF THE PROJECT

Source : Risk Based Inspection, Base Resource Documents; API Publication 581, 2000

(2.2) Results of incident severity analysis

In analyzing the level of severity and modeling the accidental release and combustion of natural gas, BREEZE HAZ mathematical model is employed. Consideration is based on the nature of the accidental release (sudden or gradual) and nature of the combustion (sudden or delayed). The findings from the case study are as follows:

(a) Natural gas transmission pipeline system / diesel transportation pipeline system

– In the case that the gas control system is immediately activated after the accidental release

- In the case that the gas control system is not immediately activated after the incident resulting in the release of the natural gas for 10 min. (The duration of 10 min is used here because the probability that a leak of 1 inch can occur is the highest and the duration of the accidental release through the leak of this size as postulated by API is 10 min.)

(b) Diesel storage tank

– In the case that the diesel control system is immediately activated after the accidental release

- In the case that the diesel system is not immediately activated after the incident resulting in the release for 20 min. (The duration of 20 min is used here because the probability that a leak of 1 inch can occur is the highest and the duration of the accidental release through the leak of this size as postulated by API is 20 min.)

Based on the general condition of the accidental release as well as the probability of the consequent combustion, probability of ignition in the form of jet fire is

the highest for natural gas accidental release. For diesel accidental release, probabilities of combustion in the form of pool fire and VCE are the highest. To assess the severity of the incident, the results of the calculation of the distance of thermal radiation and the pressure impact are compared with the criteria set to determine the impacts to equipment and personnel as caused by different degrees of thermal energy as well as impact from the pressure, with reference to the World Bank's guidelines stated in World Bank Technical Paper No.55 (1989) as shown in **Table 5.1.4.6-6**.

Regarding the results of the assessment of different cases of hazard in the project with respect to the areas with probability of accidental release, the case study of which is as follows:

Natural gas transmission pipeline

- The radius of thermal radiation at different energy levels from the area of the pipeline connecting the MRS to the area of the gas compressor, 18 inches in diameter and 125 m in length, in the cases of combustion in the form of jet fire through a leak of 1 inch and from rupture. The details are shown in **Figure 5.1.4.6-4**.

- The radius of thermal radiation at different energy levels from the area of the pipeline connecting the gas compressor to the area where the gas is relayed to the 12 inches in diameter pipeline, 18 inches in diameter and 125 m and 350 m in length, in the cases of ignition in the form of jet fire through a leak of 1 inch and from rupture. The details are shown in **Figure 5.1.4.6-5**.

- The radius of thermal radiation at different energy levels from the area where the gas is relayed from the 18 inches in diameter pipeline to the flow meter, 12 inches in diameter and 130, 220, 130, and 220 m in length, in the cases of ignition in the form of jet fire through a leak of 1 inch and from rupture. The details are shown in **Figure 5.5.6-6** (exhibiting the case of 220 m in length, which is considered the worst case scenario.)

- The radius of thermal radiation at different energy levels from the area of the pipeline connecting the flow meter to the gas turbine, 12 inches in diameter and 40 m in length, in the cases of ignition in the form of jet fire through a leak of 1 inch and from rupture. The details are shown in **Figure 5.1.4.6-7**.

• Diesel transportation pipeline

- The radius of thermal radiation at different energy levels from the area of the diesel transportation pipeline of 12 inches in diameter (which is the main pipeline connected from the storage tank to the electricity generation unit), with the length of approximately 150 m from the storage tank to the fuel oil transfer pump, in the cases of ignition in the form of fireball and VCE through a leak of 1 inch and from rupture. The details are shown in **Figure 5.1.4.6-8** and **Figure 5.1.4.6-9**.
















- The radius of thermal radiation at different energy levels from the diesel transportation pipeline of 12 inches in diameter (which is the main pipeline connected from the fuel oil transfer pump to each individual gas turbine), with the length of approximately 50 m, in the cases of combustion in the form of fireball and VCE through a leak of 1 inch and from rupture. The details are shown in **Figure 5.1.4.6-10** and **Figure 5.1.4.6-11**.

- The radius of thermal radiation at different energy levels from the diesel transportation pipeline of 10 inches in diameter of 140 m in length in total, which is connected from the aforementioned pipeline of 12 inches in diameter, then to the pipeline of 8 inches in diameter (100 m in length), then to the pipeline of 6 inches in diameter (90, 120, 120, and 210 m in length – The Figure exhibits the case of 210-meterlong pipeline, which is considered the worst case scenario) before diverting to the main fuel oil pump in each generating unit in the cases of ignition in the form of fireball and VCE through a leak of 1 inch and from rupture. The details are shown from **Figure 5.1.4.6-12** to **Figure 5.1.4.6-17**.

• Diesel storage tank

The radius of thermal radiation at different energy levels from the area of the diesel storage tank, in the cases of ignition in the form of pool fire, fireball and VCE through a leak of 1 inch and from rupture. The details of the radius of thermal radiation are shown in Table 5.1.4.6-17 and from Figure 5.1.4.6-18 to Figure 5.1.4.6-19.

TABLE 5.1.4.6-17

AFFECTED AREA FROM IGNITION IN FORM OF POOL FIRE AT AREA OF DIESEL

Leak size	Heat level (kW/m²)	Radius of heat radiation (m)	Affect area
Leak 1 inch			
	37.5	NA	NA
	25.0	NA	NA
	12.5	9.82	Project area
	4.0	12.35	Project area
Rupture			
	37.5	76.83	Project area
	25.0	81.37	Project area
	12.5	92.00	Project area
	4.0	122.96	Project area

STORAGE TANK

Remark : ^{1/} Diesel storage tank is 37 m in diametr and 14 m in height, at pressure of 1 barg and at temperature of 27.2 °C.

- NA means that distance to this flux unable to calculate because occurring heat level is less than specified heat level.





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Environmental Report for submittal to ADB

Chapter 5











(2.3) Results of the major hazard assessment

In assessing the risk to major hazards, in line with the guidelines formulated by API, two factors are put into consideration – the frequency of the incident and the severity of the incident, as shown in **Table 5.1.4.3-6**. Probability of mishap occurring to natural gas transmission pipeline, diesel transportation pipeline and diesel storage tank (in the case of a leak of 1 inch, the leak size with the highest probability to happen) is investigated. Also, different natures of ignition are put into consideration with respect to their impacts on both the property and humans. The details are as follows.

(a) Gas transmission pipeline system

In the case of the accidental release resulting in jet fire: The energy level at 12.5 kW/m² is used in the assessment as this is the starting energy level at which can be deadly to humans. The probability of death is 1 % if the victim is at the area exposed to such an energy level for one minute. Ten-second exposure to such an energy level can inflict skin burns. Risks in different scenarios as follows are summarized in Table 5.1.4.6-18.

• For the pipeline connecting the MRS to the area of the gas compressor, 18 inches in diameter and 125 m in length, probability of accidental release and consequent ignition in the form of jet fire is 8.20×10^{-6} times/yr or 8.20 times in 1,000,000 yr (leak of 1 inch). The likelihood of severe hazard is thus at the level of 'Very Unlikely'. Also, the incident severity is at a minor level. The correlation between the frequency and severity level of the incident; therefore, reveals risk at a low level.

• For the pipeline connecting the gas compressor to the area where the gas is relayed to the 12-inch in diameter pipeline, 18 inches in diameter and 125 m in length, probability of accidental release and consequent ignition in the form of jet fire is 8.20×10^{-6} times/yr or 8.20 times in 1,000,000 yr (leak of 1 inch). The likelihood of severe hazard is thus at the level of 'Very Unlikely'. Also, the incident severity is at a minor level. The correlation between the frequency and severity level of the incident; therefore, reveals risk at a low level.

TABLE 5.1.4.6-18

RESULT OF RISK ASSESSMENT AT THE AREA ON NATURAL GAS PIPELINE OF THE

PROJECT

Leak size (inch)	Propability of ignition in form of Jet Fire (times/yr)	Severity of mishap in case of ignition in form of Jet Fire	Level of Risk
1. Pipe connection	on of MRS to Gas Compress	or - 18 inches in diameter, 125 m in length	
1	8.20×10 ⁻⁶	Project area (Minor)	Low
	(Very Unlikely)		
Rupture	4.10×10 ⁻⁷	Project area, reservoir/pond, LLIT (Thailand) Co.,	Low
	(Very Unlikely)	Ltd. (Minor)	
2. Pipe connection length	on of Gas Compressor to re	lay point to 12-inch pipeline - 18 inches in diameter	, 125 m in
1	8.20×10 ⁻⁶	Project area (Minor)	Low
	(Very Unlikely)		
Rupture	4.10×10 ⁻⁷	Project area, reservoir/pond, LLIT (Thailand) Co.,	Low
	(Very Unlikely)	Ltd. (Minor)	
3. Pipe connection length	on of Gas Compressor ot re	lay point to 12-inch pipeline - 18 inches in diameter	, 350 m in
1	2.30×10 ⁻⁵	Project area (Minor)	Low
	(Very Unlikely)		
Rupture	1.15×10 ⁻⁶	Project area, LLIT (Thailand) Co., Ltd. (Minor)	Low
	(Very Unlikely)		
4. Pipe connection	n of relay point of 18-inch pip	peline to flow meter -12 inches in diameter, 130 m in ler	ngth
1	1.28×10 ⁻⁵	Project area (Minor)	Low
	(Very Unlikely)		
Rupture	8.53×10 ⁻⁷	Project area, LLIT (Thailand) Co., Ltd. (Minor)	Low
	(Very Unlikely)		
5. Pipe connection	n of relay point of 18-inch pip	peline to flow meter -12 inches in diameter, 220 m in ler	ngth
1	2.17×10 ⁻⁵	Project area (Minor)	Low
	(Very Unlikely)		
Rupture	1.44×10 ⁻⁶	Project area, LLIT (Thailand) Co., Ltd. (Minor)	Low
	(Very Unlikely)		
6. Pipe connection	on of flow meter to gas turk	pine - 12 inches in diameter, 40 m in length	
1	3.94×10 ⁻⁶	Project area (Minor)	Low
	(Very Unlikely)		
Rupture	2.62×10 ⁻⁷	Project area (Minor)	Low
	(Very Unlikely)		

• For the pipeline connecting the gas compressor to the area where the gas is relayed to the 12-inch in diameter pipeline, 18 inches in diameter and 350 m in length, probability of accidental release and consequent ignition in the form of jet fire is 2.30×10^{-5} times/yr or 2.30 times in 100,000 yr (leak of 1 inch). The likelihood of severe hazard is thus at the level of 'Very Unlikely'. Also, the incident severity is at a minor level. The correlation between the frequency and severity level of the incident; therefore, reveals risk at a low level.

• For the pipeline connecting the area where the gas is relayed from the 18-inch in diameter pipeline to the flow meter, 12 inches in diameter and 130 m in length, probability of accidental release and consequent ignition in the form of jet fire is 1.28×10^{-5} times/yr or 1.28 times in 100,000 yr (leak of 1 inch). The likelihood of severe hazard is thus at the level of 'Very Unlikely'. Also, the incident severity is at a minor level. The correlation between the frequency and severity level of the incident; therefore, reveals risk at a low level.

• For the pipeline connecting the area where the gas is relayed from the 18-inch in diameter pipeline to the flow meter, 12 inches in diameter and 220 m in length, probability of accidental release and consequent ignition in the form of jet fire is 2.17×10^{-5} times/yr or 2.17 times in 1,000,000 yr (leak of 1 inch). The likelihood of severe hazard is thus at the level of 'Very Unlikely'. Also, the incident severity is at a minor level. The correlation between the frequency and severity level of the incident; therefore, reveals risk at a low level.

• For the pipeline connecting the flow meter to the gas turbine, 12 inches in diameter and 40 m in length, probability of accidental release and consequent ignition in the form of jet fire is 3.94×10^{-6} times/yr or 3.94 times in 1,000,000 yr (leak of 1 inch). The likelihood of severe hazard is thus at the level of 'Very Unlikely'. Also, the incident severity is at a minor level. The correlation between the frequency and severity level of the incident; therefore, reveals risk at a low level.

(b) Diesel transportation pipeline system

In the case of the accidental release resulting in fireballs: The energy level at 12.5 kW/m² is used in the assessment as this is the starting energy level at which is fatal to humans. The probability of death is 1 % if the victim is at the area exposed to such an energy level for one minute. Ten-second exposure to such an energy level can inflict skin burns. Risks in different scenarios as follows are summarized in Table 5.1.4.6-19.

	TABLE 5.1.4.6-19				
R	ESULT OF RISK A	SSESSMENT AT	THE AREA OF DIESEL OIL TRANSP	ORTATION PIPELINE OF THE PROJECT	
Pucncture	Propability of ig	nition (times/yr)	Severity of mis	shap in case of ignition	Level of Rist
(inch)	Fireball	VCE	Fireball	VCE	
1. Pipe connection c	of diesel tank to elec	tricity generating uni	it - 12 inches in diameter, 150 m in length		
1	1.48×10 ⁻⁴	1.48×10 ⁻⁴	Project area, LLIT (Thailand) Co., Ltd. (Minor)	Project area, LLIT (Thailand) Co., Ltd. (Minor)	Low
	(Very Unlikely)	(Very Unlikely)			
Ruptrue	9.84×10 ⁻⁶	9.84×10 ⁻⁶	Project area, LLIT (Thailand) Co., Ltd.,	Project area, LLIT (Thailand) Co., Ltd., industrial	Low
	(Very Unlikely)	(Very Unlikely)	industrial estate, Wat Chomphon Chao	estate, Wat Chomphon Chao Phraya, unused land,	
	1	1	Phraya, rubber tree, unused land,	rubber tree, reservoir/pond, Chumchon Borisat	
	1	1	residential area, reservoir/pond, Chumchon	Namtan Tawan-aok School, chicken farm, multi-	
	1		Borisat Namtan Tawan-aok School, chicken	pureposes building of Chomphon Chao Phraya Sub-	
	1		farm, multi-pureposes building of	district Municipality, residential area, field	
	1	1	Chomphon Chao Phraya Sub-district	crop/cassava/pineapple (Major)	
	ı!		Municipality, Oil Palm (Major)		
2. Pipe connection of	of fuel Oil Transfer P	ump to relay point t	o gas turbine - 12 inches in diameter, 50 m	n in length	
1	4.92×10 ⁻⁵	4.92×10 ⁻⁵	Project area, LLIT (Thailand) Co., Ltd. (Minor)	Project area, LLIT (Thailand) Co., Ltd. (Minor)	Low
	(Very Unlikely)	(Very Unlikely)			
Ruptrue	3.28×10 ⁻⁶	3.28×10 ⁻⁶	Project area, LLIT (Thailand) Co., Ltd.,	Project area, LLIT (Thailand) Co., Ltd., industrial	Low
	(Very Unlikely)	(Very Unlikely)	industrial estate, rubber tree, Wat	estate, Wat Chomphon Chao Phraya, unused land,	
	1		Chomphon Chao Phraya, unused land,	rubber tree, reservoir/pond, Chumchon Borisat	
	1		residential area, reservoir/pond, Chumchon	Namtan Tawan-aok School, residential area, field	
	1		Borisat Namtan Tawan-aok School, field	crop/cassava/pineapple (Major)	
	ı!		crop/cassava/pineapple (Major)		

Environmental Report for submittal to ADB Chapter 5 Sriracha Power Plant Project Gulf SRC Co., Ltd. Anticipated Environmental Impacts and Mitigations

	Pucncture Propability of ignition (times/yr) Severity of mishap in case of ignition					
Puchcture			nition (times/yr)	Seventy of mis	shap in case of ignition	Level of Rist
	(inch) Fireball VC		VCE	Fireball	VCE	
3. 1	10-inch Pipe wi	th 140 m in length				
	1	1.38×10-4	1.38×10-4	Project area, LLIT (Thailand) Co., Ltd. (Minor)	Project area, LLIT (Thailand) Co., Ltd. (Minor)	Low
		(Very Unlikely)	(Very Unlikely)			
	Ruptrue	9.19×10-6	9.19×10-6	Project area, LLIT (Thailand) Co., Ltd.,	Project area, LLIT (Thailand) Co., Ltd., rubber tree,	Low
		(Very Unlikely)	(Very Unlikely)	rubber tree, residential area, industrial	residential area, industrial estate, Wat Chomphon	
				estate, Wat Chomphon Chao Phraya,	Chao Phraya, unused land, reservoir/pond,	
				unused land, reservoir/pond, Chumchon	Chumchon Borisat Namtan Tawan-aok School	
				Borisat Namtan Tawan-aok School (Major)	(Major)	
4. 8	8-inch Pipe witl	n 100 m in length				
	1	9.84×10-5	9.84×10-5	Project area, LLIT (Thailand) Co., Ltd. (Minor)	Project area, LLIT (Thailand) Co., Ltd. (Minor)	Low
		(Very Unlikely)	(Very Unlikely)			
	Ruptrue	6.56×10-6	6.56×10-6	Project area, LLIT (Thailand) Co., Ltd.,	Project area, LLIT (Thailand) Co., Ltd.,	Low
		(Very Unlikely)	(Very Unlikely)	reservoir/pond, industrial estate, rubber	reservoir/pond, industrial estate, rubber tree,	
				tree (Minor)	Chumchon Borisat Namtan Tawan-aok School, Wat	
					Chomphon Chao Phraya (Minor)	
. 6	6-inch Pipe with	n 90 m in length				
	1	1.18×10-4	1.18×10-4	Project area (Minor)	Project area, LLIT (Thailand) Co., Ltd. (Minor)	Low
		(Very Unlikely)	(Very Unlikely)			
	Ruptrue	2.36×10-5	2.36×10-5	Project area, LLIT (Thailand) Co., Ltd.,	Project area, LLIT (Thailand) Co., Ltd., reservoir/pond,	Low
		(Very Unlikely)	(Very Unlikely)	reservoir/pond, Chumchon Borisat Namtan	Chumchon Borisat Namtan Tawan-aok School,	
				Tawan-aok School, industrial estate, Wat	industrial estate, Wat Chomphon Chao Phraya, rubber	
				Chomphon Chao Phraya, rubber tree	tree (Minor)	
				(Minor)		

TABLE 5.1.4.6-19

Environmental Report for submittal to ADB Sriracha Power Plant Project Gulf SRC Co., Ltd.

Chapter 5 Anticipated Environmental Impacts and Mitigations

RESU	LT OF RISK ASSE	SSMENT AT THE	AREA OF DIESEL OIL TRANSPORT	ATION PIPELINE OF THE PROJECT (CONT	'D)
Pucncture	Propability of ig	nition (times/yr)	Severity of mi	shap in case of ignition	Loval of Pist
(inch)	Fireball	VCE	Fireball	VCE	
6. 6-inch Pipe with	120 m in length				
1	1.57×10 ⁻⁴	1.57×10 ⁻⁴	Project area (Minor)	Project area, LLIT (Thailand) Co., Ltd. (Minor)	Low
	(Very Unlikely)	(Very Unlikely)			
Ruptrue	3.15×10 ⁻⁵	3.15×10 ⁻⁵	Project area, LLIT (Thailand) Co., Ltd.,	Project area, LLIT (Thailand) Co., Ltd.,	Low
	(Very Unlikely)	(Very Unlikely)	reservoir/pond, Chumchon Borisat Namtan	reservoir/pond, Chumchon Borisat Namtan Tawan-	
			Tawan-aok School, industrial estate, Wat	aok School, industrial estate, Wat Chomphon Chao	
			Chomphon Chao Phraya, rubber tree	Phraya, rubber tree (Minor)	
			(Minor)		
7. 6-inch Pi	pe with 210 m in len	gth			
1	2.76×10 ⁻⁴	2.76×10 ⁻⁴	Project area (Minor)	Project area, LLIT (Thailand) Co., Ltd. (Minor)	Low
	(Very Unlikely)	(Very Unlikely)			
Ruptrue	8.00×10 ⁻⁸	8.00×10 ⁻⁸	Project area, LLIT (Thailand) Co., Ltd.,	Project area, LLIT (Thailand) Co., Ltd.,	Low
	(Very Unlikely)	(Very Unlikely)	reservoir/pond, Chumchon Borisat Namtan	reservoir/pond, Chumchon Borisat Namtan Tawan-	
			Tawan-aok School, industrial estate, Wat	aok School, industrial estate, Wat Chomphon Chao	
			Chomphon Chao Phraya, rubber tree	Phraya, rubber tree (Minor)	
			(Minor)		

TABLE 5.1.4.6-19

RNP/ENV/RT5703/P2810/CH5_ADB_part5

Environmental Report for submittal to ADB Sriracha Power Plant Project Gulf SRC Co., Ltd.

Chapter 5 Anticipated Environmental Impacts and Mitigations • For the pipeline which is the main pipeline connected from the storage tank to the electricity generation unit, 12 inches in diameter and 150 m in length

Probability of accidental release and consequent ignition in the form of fireballs in the area of the storage tank is 1.48×10^{-4} times/yr or 1.48 times in 10,000 yr (leak of 1 inch). The likelihood of severe hazard is thus at the level of 'Very Unlikely'. Also, the incident severity is at a minor level. The correlation between the frequency and severity level of the incident; therefore, reveals risk at a low level.

• For the pipeline connected from the fuel oil transfer pump to each individual gas turbine, 12 inches in diameter and 50 m in length

Probability of accidental release and consequent ignition in the form of fireballs is 4.92×10^{-5} times/yr or 4.92 times in 100,000 yr (leak of 1 inch). The likelihood of severe hazard is thus at the level of 'Very Unlikely'. Also, the incident severity is at a minor level. The correlation between the frequency and severity level of the incident; therefore, reveals risk at a low level.

• For the pipeline of 10 inches in diameter and 140 m in length

Probability of accidental release and consequent ignition in the form of fireballs is 1.38×10^{-4} times/yr or 1.38 times in 10,000 yr (leak of 1 inch). The likelihood of severe hazard is thus at the level of 'Very Unlikely'. Also, the incident severity is at a minor level. The correlation between the frequency and severity level of the incident; therefore, reveals risk at a low level.

• For the pipeline of 8 inches in diameter, 100 m in length and

Probability of accidental release and consequent ignition in the form of fireballs is 9.84×10^{-5} times/yr or 9.84 times in 100,000 yr (leak of 1 inch). The likelihood of severe hazard is thus at the level of 'Very Unlikely'. Also, the incident severity is at a minor level. The correlation between the frequency and severity level of the incident; therefore, reveals risk at a low level.

• For the pipeline of 6 inches in diameter and 90 m in length

Probability of accidental release and consequent ignition in the form of fireballs is 1.80×10^{-4} times/yr or 1.80 times in 10,000 yr (leak of 1 inch). The likelihood of severe hazard is thus at the level of 'Very Unlikely'. Also, the incident severity is at a minor level. The correlation between the frequency and severity level of the incident; therefore, reveals risk at a low level.

leak of 1 inch

• For the pipeline of 6 inches in diameter and 120 m in length Probability of accidental release and consequent ignition in the

form of fireballs is 1.57×10^{-4} times/yr or 1.57 times in 10,000 yr (leak of 1 inch). The likelihood of severe hazard is thus at the level of 'Very Unlikely'. Also, the incident severity is at a minor level. The correlation between the frequency and severity level of the incident; therefore, reveals risk at a low level.

• For the pipeline of 6 inches in diameter and 210 m in length

Probability of accidental release and consequent ignition in the form of fireballs is 2.76×10^{-4} times/yr or 2.76 times in 10,000 yr (leak of 1 inch). The likelihood of severe hazard is thus at the level of 'Very Unlikely'. Also, the incident severity is at a minor level. The correlation between the frequency and severity level of the incident; therefore, reveals risk at a low level.

The case of Leak and VCE Flaming

The case of leak and VCE flaming consider in pressure at 0.069 Bar, since this level is severve damage to buildings and equipments are show in Table 5.1.4.6-19.

• For the pipeline link of diesel storage and electricity generating unit of 12 inches in diameter and 150 m in length

Probability of accidental release and VCE Flaming is 1.48×10^{-4} times/yr or 1 times in 10,000 yr (leak of 1 inch). The likelihood of severe hazard is thus at the level of 'Very Unlikely'. Also, the incident severity is at a minor level. The correlation between the frequency and severity level of the incident; therefore, reveals risk at a low level.

• For the pipeline link of fuel oil transfer pump and gas turbine unit of 12 inches in diameter and 50 m in length

Probability of accidental release and VCE Flaming is 4.92×10^{-5} times/yr or 1 times in 100,000 yr (leak of 1 inch). The likelihood of severe hazard is thus at the level of 'Very Unlikely'. Also, the incident severity is at a minor level. The correlation between the frequency and severity level of the incident; therefore, reveals risk at a low level.

• For the pipeline of 10 inches in diameter and 140 m in length Probability of accidental release and VCE Flaming is 1.38×10⁻⁴

times/yr or 1.38 times in 10,000 yr (leak of 1 inch). The likelihood of severe hazard is thus at the level of 'Very Unlikely'. Also, the incident severity is at a minor level. The correlation between the frequency and severity level of the incident; therefore, reveals risk at a low level.

• For the pipeline of 8 inches in diameter and 100 m in length and leak of 1 inch

Probability of accidental release and VCE Flaming is 9.84×10^{-5} times/yr or 9.84 times in 10,000 yr (leak of 1 inch). The likelihood of severe hazard is thus at the level of 'Very Unlikely'. Also, the incident severity is at a minor level. The correlation between the frequency and severity level of the incident; therefore, reveals risk at a low level.

• For the pipeline of 6 inches in diameter and 90 m in length

Probability of accidental release and VCE Flaming is 1.80×10^{-4} times/yr or 1.80 times in 10,000 yr (leak of 1 inch). The likelihood of severe hazard is thus at the level of 'Very Unlikely'. Also, the incident severity is at a minor level. The correlation between the frequency and severity level of the incident; therefore, reveals risk at a low level.

• For the pipeline of 6 inches in diameter and 120 m in length Probability of accidental release and VCE Flaming is 1.57×10⁻⁴

times/yr or 1.57 times in 10,000 yr (leak of 1 inch). The likelihood of severe hazard is thus at the level of 'Very Unlikely'. Also, the incident severity is at a minor level. The correlation between the frequency and severity level of the incident; therefore, reveals risk at a low level.

• For the pipeline of 6 inches in diameter and 210 m in length

Probability of accidental release and VCE Flaming is 2.76×10^{-4} times/yr or 2.76 times in 10,000 yr (leak of 1 inch). The likelihood of severe hazard is thus at the level of 'Very Unlikely'. Also, the incident severity is at a minor level. The correlation between the frequency and severity level of the incident; therefore, reveals risk at a low level.

(c) Diesel storage tank

• In the case of the accidental release resulting in pool fire

The energy level at 12.5 kW/m² is used in the assessment as this is the starting energy level at which can be fatal to humans. The probability of death is 1 % if the victim is at the area exposed to such an energy level for one minute. Ten-second exposure to such an energy level can inflict skin burns. Risks in different scenarios as follows are summarized in **Table 5.1.4.6-20**.

	RESULT OF RISK ASSESSMEHT AT THE AREA OF DIESEL OIL STORAGE TANK OF THE PROJECT						
Leak size	Propabil	ity of ignition (ti	mes/yr)		Severity of mishap in case o	f ignition	Level of Risk
(inch)	Pool Fire	Fireball	VCE	Pool Fire	Fireball	VCE	
1	4×10 ⁻⁶	1×10 ⁻⁴	1×10 ⁻⁴	Project area	Project area, LLIT (Thailand) Co.,	Project area, LLIT (Thailand) Co.,	Low
	(Very Unlikely)	(Very Unlikely)	(Very Unlikely)	(Minor)	Ltd. (Minor)	Ltd., ruber tree (Minor)	
Ruptrue	2.8×10 ⁻⁹	7×10 ⁻⁸	7×10 ⁻⁸	Project area	Project area, LLIT (Thailand) Co.,	Project area, LLIT (Thailand) Co.,	Low
	(Very Unlikely)	(Very Unlikely)	(Very Unlikely)	(Minor)	Ltd., reservoir/pond, residential	Ltd., Wat Chomphon Chao	
					area, multi-pureposes building,	Phraya, rubber tree,	
					Chumchon Borisat Namtan	reservoir/pond, Chumchon	
					Tawan-aok School, industrial	Borisat Namtan Tawan-aok	
					estate, unused land, Wat	School, industrial estate,	
					Chomphon Chao Phraya,	unused land, residential area,	
					chicken farm, rubber tree, field	multi-pureposes building of	
					crop/cassava/pineapple (Major)	Chomphon Chao Phraya Sub-	
						district Municipality, oil palm,	
						chicken farm, , field	
						crop/cassava/ pineapple (Major)	

TABLE 5.1.4.6-20

RNP/ENV/RT5703/P2810/CH5_ADB_part5

Environmental Report for submittal to ADB Chapter 5 Sriracha Power Plant Project Gulf SRC Co., Ltd. Anticipated Environmental Impacts and Mitigations

For the area where the diesel storage tanks are located, probability of accidental release and consequent ignition in the form of pool fire is 4.00×10^{-6} times/yr or 4.00 times in 1,000,000 yr (leak of 1 inch). The likelihood of severe hazard is thus at the level of 'Very Unlikely'. Also, the incident severity is at a minor level. The correlation between the frequency and severity level of the incident; therefore, reveals risk at a low level.

• In case of the accidental release resulting in fireball

The energy level at 12.5 kW/m² is used in the assessment as this is the starting energy level at which can be fatal to humans. The probability of death is 1 % if the victim is at the area exposed to such an energy level for one minute. Ten-second exposure to such an energy level can inflict skin burns. Risks in different scenarios as follows are summarized in **Table 5.1.4.6-20**.

For the area where the diesel storage tanks are located, probability of accidental release and consequent ignition in the form of fireball is 1.00×10^{-4} times/yr or 1 times in 10,000 yr (leak of 1 inch). The likelihood of severe hazard is thus at the level of 'Very Unlikely'. Also, the incident severity is at a minor level. The correlation between the frequency and severity level of the incident; therefore, reveals risk at a low level.

• In case of the accidental release resulting in VCE

The pressure of 0.069 bar is used in the assessment as this is the starting pressure at which can cause severe damage to construction and nearby equipmentfatal to humans. The probability of death is 1 % if the victim is at the area exposed to such an energy level for one minute. Ten-second exposure to such an energy level can inflict skin burns. Risks in different scenarios as follows are summarized in **Table 5.1.4.6-20**.

For the area where the diesel storage tanks are located, probability of accidental release and consequent ignition in the form of VCE is 1.00×10^{-4} times/yr or 1 times in 10,000 yr (leak of 1 inch). The likelihood of severe hazard is thus at the level of 'Very Unlikely'. Also, the incident severity is at a minor level. The correlation between the frequency and severity level of the incident; therefore, reveals risk at a low level.

5.1.4.6.2 Assessment of Major Hazards resulting from Leakage of Chemical Substances

In assessing level of severity of major hazards resulting from mishaps occurring where chemical substances are used and stored, the Material Safety Data Sheet (MSDS) is referred to. According to the acts referred to in the MSDS developed by the Hazardous Material and Chemical Substance Information Center, the Pollution Control Department, which include the Hazardous Material Act B.E. 2535, the Arms and Ammunition Control Act B.E.2530, and the Labor Protection Act B.E.2541; among the 12 types of chemical substances used in the project, three are listed in the Hazardous Material Act B.E.2535 and the Labor Protection Act B.E.2541 – which are sulfuric acid, sodium hydroxide, and corrosion inhibitor.

Regarding the chemical substances that need to be stored within the project premises, specific storage areas are allotted for different types of chemical substances depending on their properties with consideration on safety from possible chemical reaction. Furthermore, flammable materials are isolated in designated areas. The measures in dealing with the storage of chemical substances are as follows.

(1) Safety data on every chemical substance used in the project are to be collected, filed and displayed on the notice board or label attached to the container of each chemical substance.

(2) Chemical substances which quickly react to each other such as acid and alkali, or flammable chemical substances are to be kept separately.

(3) The places where chemical substances are kept must be well ventilated for the air to be well-circulated.

(4) Curbs are to constructed around storage tanks large enough to contain the chemical substance accidentally released, preventing the spread of the chemical substance on the building floor or into the gutters.

(5) Wall posters warning against any action causing sparks in the premises are to be placed.

(6) Appropriate and sufficient firefighting equipment is to be provided in the premises.

Probability of incidents is considered low for the following reasons. First of all, the locations where the chemical substances are kept and used are in the power plant compound accessible only to the power plant staff. Moreover, several measures are taken in managing the storage of chemical substances. Warning posters are to be placed. The material safety data sheet is to be prepared for the staff working in the said locations. To be provided to the staff whose duty involves transportation and use of chemical substances are safety and protective equipment such as safety shower and eyewash kits, protective masks, gloves; as well as appropriate tools for transporting chemical substances. Equipment required in cleaning and disposing accidentally released chemical substances

is also readily and sufficiently available. Advice regarding the material safety data sheet is also provided to new staff members in their induction.

In addition, the toxicity in case of accidental release of liquid ammonia from the storage tank is assessed by the consultant. This is so because approximately 6,900 m³/y of 25 % liquid ammonia is to be used in the project to control the nitrogen oxide in the hot gas resulting from the combustion of the gas turbine. The ammonia is to be stored in 4 tanks of 80 m³, with curbs built around, in the building for chemical substance storage.

With reference to the MSDS, 25 % aqueous ammonia is non-flammable. However, it has toxicological impact with the LCL₀ value of 5,000 ppm, the lowest concentration which can be deadly to humans if they are exposed to the said amount; and the LD 50 value of 350 mg/kg (as experimented with mice). Being a model suitable for liquid spill, AFTOX Model (developed from the U.S. Air Force's Toxic Corridor Model and a sub-model of BREEZE HAZ Model) is employed in assessing the severity, which can be subsequently used in the risk assessment.

(1) Formulation of accidental release hypothesis

For accidental release of aqueous ammonia, assessment is based on the isolation system administered by the staff, which is regarded as Class B. As the pipeline connecting the aqueous ammonia storage tank, the area with probability of accidental release, is of the size of 1 inch; the worst case scenario (rupture) equals the size of the pipeline in relation with the duration of accidental release of 20 min.

• Release rate

Aqueous ammonia is stored in 4 tanks of 80 m³, 4.6 m in diameter, and 5.2 m in height each. The rate is assessed at ambient conditions, as shown in **Table 5.1.4.6-21**.

• Analysis of areas at risk

Most of the areas with probability of accidental release are those where aqueous ammonia storage tanks are connected.

TABLE 5.1.4.6-21

AQUEPIS AMMONIA RELEASE RATE IN RELATIONSHIP WITH SIZE OF LEAK

Leak size	Release duration	Release rate	Release quantity
(inch)	(min)	(kg/sec)	(kg)
Pipe rupture	20	1.03	4,428.19

Remark : Pipe connecting with aqueous ammonia tank has 1 inch in diameter.

- (2) Risk assessment
 - Probability of Risk

Assessment in case there is breakage in the area of the flange or pipe fitting, with the size of the leak assessed regarding the diameter of the largest pipe fitting, which is 1 inch, probability of incident is equal to 2×10^{-5} times/yr, as shown in **Table 5.1.4.6-9**.

• Probability of Risk and toxicity of aqueous ammonia

With reference to MSDS, flash fire can incur if aqueous ammonia turns into vapor in a certain sufficient amount. With reference to the levels of likelihood of major hazards set in line with U.S.EPA's guidelines (1990), the details of which are shown in **Table 5.1.4.6-5**; the project's likelihood of severe hazards is at the level of 'Very Unlikely', as shown in **Table 5.1.4.6-22**.

TABLE 5.1.4.6-22

PROBABILITY OF MAJOR HAZARD OCCURRENCE AT THE AREA OF AQUEOUS

Dine diameter/	Propability	Probability of ignition	Propability of major
Pipe diameter/	of leakage	(times/yr)	hazard occurrence
Leak size	(times/yr) Flash Fire		Flash Fire
At the area of aqueous ammonia storage tank			
Pipe rupture	2×10 ⁻⁵	1.2×10 ⁻⁶	Very Unlikely

AMMONIA STORAGE TANK OF THE PROJECT

Source : Risk Based Inspection, Base Resource Documents; API Publication 581, 2000

Aqueous ammonia 25 %, with reference to MSDS, is non-flammable, but has toxicological impact – with the Lowest published letal concentration (LCLO) of 5,000 ppm, the lowest that can be fatal if inhaled. Being a model suitable for liquid spill, AFTOX Model (developed from the U.S. Air Force's Toxic Corridor Model and a sub-model of BREEZE HAZ Model) is employed by the consultant. The results of the analysis based on the AFTOX model, with consideration on the radius of release from the aqueous ammonia storage tank in the case of rupture, and the affecting radius of concentration are shown in **Table 5.1.4.6-23**.

TABLE 5.1.4.6-23

AFFECTED AREA FROM ACCIDENTAL RELEASE AT THE AREA OF

AQUEOUS AMMONIA TANK

Leak size	Radius of leakage (m)	Affected area
- Pipe rupture ^{1/}	284.44	Project area
- 1/ .		

Remark: ^{1/} Assessment considerer the lowest concentration of ammonia of 5,000 ppm

• Results of analysis of accidental release risk levels

In the case of accidental release analysis based on AFTOX model Based on AFTOX model, probability of accidental release is 1.20×10^{-6}

times/yr or 120 times in 100,000 yr (in the case of rupture). The likelihood of severe hazard is thus at the level of 'Very Unlikely' (**Table 5.1.4.6-24**). Also, the incident severity is at a minor level. The correlation between the frequency and severity level of the incident; therefore, reveals risk at a low level.

TABLE 5.1.4.6-24

RESULT OF RISK ASSESSMENT AT THE AREA OF AMMONIA STORAGE TANK

Leak	Propability of ignition in	Severity of mishap in case of	Level of
(inch)	from of flash fire (times/yr)	ignition in from of flash fire	risk
Pipe rupture	1.2×10 ⁻⁶ (Very Unlikely)	Project area	Low

OF THE PROJECT

5.1.4.6.3 Assessment of Major Hazards resulting from Mechanical Failure

(1) Screening of things that pose risks and may be hazardous in the project

Screening things that pose risks and may be hazardous in the project or listing them helps lead to revision of the project's fundamental production process by assessing the manners and procedures of production with likelihood of serious incidents. The data collected are to be verified prior to being further employed in the major hazard assessment.

Regarding the project's electricity production process, things that pose risks and may be hazardous include the gas turbine, steam boiler, steam turbine, electricity generator, and electricity transformer, for example.

(2) Identification of hazards

Listing things that pose risks and may be hazardous in the project helps lead to identification of risks and hazards. To analyze the causes and results of the faults identified and define the nature of the related mishaps, Fault Tree Analysis (FTA) is employed. FTA is a tool for safety analysis whereby undesired outcomes from an initiating event are assessed. The causes of the initiating event are also assessed with respect to their natures represented by symbols such as 'And Gate', 'Or Gate', or others (**Table 5.1.4.6-25**). Possible sequences of events that could result in an incident are analyzed until preventive measures can be formulated. Steps in the Fault Tree Analysis are as follows: (a) Select a failure possible to happen as the 'top event'.

(b) Assess the failure - which may happen because of only one of certain possible event inputs, represented by the symbol "or".

(c) In case the failure happens because of several possible event inputs, this is represented by the symbol "and".

(d) The event input identified may happen because of another possible event input or several possible event inputs, for which the symbol "or" or "and" is used depending on the case.

(e) The final input can be as follows:

Basic event

- Undeveloped event (can be because it is of insufficient consequence or because information is unavailable)

– External event (including natural phenomena such as thunder and

lightning)

The results of hazard identification are shown from Figure 5.1.4.6-20 to Figure 5.1.4.6-23.

TABLE 5.1.4.6-25

SYMBOLS USED IN HAZARD IDENTIFICATION ANALYSIS

Symbol	Name	Meaning
	AND Gate	An event occurs if several input conditions are met
	Or Gate	An event occurs as long as one of the input events takes place
\bigcirc	Basic Event	A basic initiating fault requiring no further investigation for its cause. It is the root cause of an incident.
	Fault Tree Event	An intermediate event that causes another event to happen, leading to the failure which is the top event
\bigcirc	Undeveloped Event	An intermediate event requiring no further investigation for its cause because of a lack of supporting information.
	External Event	An external event or factor causing a failure to occur

Source : Regulations of Department of Industrial Works on criteria in hazard identification, risk assessment, and formulation of risk management plans B.E.2543.



Figure 5.1.4.6-20 : Fault Tree Analysis in the Case of Gas Turbine Explosion





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Chapter 5



(3) Risk assessment

Risk assessment involves the analysis of the probability and severity of identified hazards. In this study, major hazards having been identified are to be analyzed with respect to their risk level - whether they are at a low, acceptable, high, or unacceptable level of risk. The data acquired are to be used in the risk control management. The hazard identification reveals that possible hazards include explosion of the steam boiler, steam turbine, electricity generator; and accidental release of chemical substances. The criteria and results of the assessment are in accordance with those stipulated in the Regulations of Department of Industrial Works on criteria in hazard identification, risk assessment, and formulation of risk management plans B.E.2543. In the assessment the probability of the incident is multiplied by the severity level that impacts an individual/community/environment and property, as follows:

Level	Definition
1	Unlikely, e.g., never occurred in the period of 10 yr
2	Reasonably Likely, e.g. occurred once in the range of 5-10 yr
3	Likely, e.g. occurred once in the range of 1-5 yr
4	Common, e.g., occurred more than once in a year

- (a) Consideration on incident probabilities, which were classified into 4 levels;
- (b) Consideration on severity of incidents impacting on people, communities,

properties and environment

(b.1) Prioritization of severity of incidents impacting on people

Level	Severity	Definition	
1	Minor	Small injury at first aid level	
2	Moderate	Injury needing medical care	
3	Major	Severe injury or illness	
4	Catastrophic	Disability or death	

(b.2) Prioritization of severity of incidents impacting on communities

Level	Severity	Definition	
1	Minor	No impacts on communities around the plant or small	
		impacts	
2	Moderate	Impacts on communities around the plant that can be	
		solved in a short time.	
3	Major	Impacts on communities around the plant, with time	
		consumed to solve.	
4	Catastrophic	Severe impacts on large areas of communities, or	
		requires action from governmental officials.	

Remark : Impacts on communities refer to disturbance to communities, injury or illness of people, damages to people and community properties.

Level	Severity	Definition	
1	Minor	Small impacts on environment that can be controlled or	
		solved.	
2	Moderate	Medium impacts on environment that can be solved in a	
		short time.	
3	Major	High impacts on environment that needs time for	
		solving.	
4	Catastrophic	Severe impacts on environment that needs resources	
		and a long time for solving.	

(b.3) Prioritization of severity of incidents impacting on environment

Remark : Impacts on environment refer to deterioration or damages to environmental resources such as air, soil and water resources, etc.

(b.4) Prioritization of severity of incidents impacting on properties

Level	Severity	Definition	
1	Minor	Small properties damaged or no damage	
2	Moderate	Medium properties damaged and production can continue.	
3	Major	Large properties damaged, some parts of production have to be stopped.	
4	Catastrophic	Large properties damaged, and production has to be stopped totally.	

Remark : For each property damage level, the plant can assign with suitability, depending on the plant capability.

(c) Risk prioritization was considered from the multiplication of probability level and severity level of impacts on people, communities, properties and environment.
Its value is differed. The maximum value was selected as the result of risk assessment.
Risk level is classified into 4 levels as follows;

Level	Severity	Definition	
1	1-2	Small properties damaged or no damage	
2	3-6	Medium properties damaged, and production can continue.	
3	8-9	Large properties damaged, some parts of production have to be stopped.	
4	12-16	Large property damaged, and production has to be stopped totally.	

Regarding information of propability of equipment failure as shown in **Table 5.1.4.6-26** and **Table 5.1.4.6-27**, the propability of hazard occurrence can be identified as follows:

TABLE 5.1.4.6-26

Incedent	Frequency (times/yr)	Propability of occurrence				
Smith and Warwick (1981)						
Power Failure (PEA)	10	4 (common)				
Limit switch failure	1×10-4	1 (unlikely)				
Level switch failure	8.2×10 ⁻⁶	1 (unlikely)				
Operator Error	1×10 ⁻³	1 (unlikely)				
Pressure control fault	1×10 ⁻⁴	1 (unlikely)				
Solenoid valve fail to close	1×10 ⁻³	1 (unlikely)				
Level alarm failure	8.2×10⁻ ⁶	1 (unlikely)				
Vent Gas failure	2×10 ⁻⁵	1 (unlikely)				
Inter-unit pipe (general)	3.5×10⁻ ⁷	1 (unlikely)				
Emergency gen. Fault	1 × 10 ⁻⁵	1 (unlikely)				
Mechanical failure	7 × 10 ⁻³	1 (unlikely)				
P. Trip signal	5.4×10 ⁻⁴	1 (unlikely)				
No immediate ignition	1.4×10 ⁻³	1 (unlikely)				
Immediate ignition	0.9386	3 (likely)				
Sudden Weather Change	1×10 ⁻²	1 (unlikely)				
Third Party Error	1×10 ⁻³	1 (unlikely)				
Impulse lines (blocked or leaking)	0.09	1 (unlikely)				
Pressure switch	0.13	2 (reasonably likely)				
Cable (fractured or severed)	0.03	1 (unlikely)				
Loss of electric power Steam	0.05	1 (unlikely)				
Relay (complete with wire)	0.08	1 (unlikely)				
Solenoid valve	0.30	3 (likely)				
Loss of electric power	0.05	1 (unlikely)				
Trip valve	0.25	3 (likely)				
Air Supply line (block, broken)	0.02	1 (unlikely)				
Loss of air supply	0.02	1 (unlikely)				
Relay, etc., as above	0.08	1 (unlikely)				
Pressure relief valve	0.02	1 (unlikely)				
Flame-failure detector	1.69	4 (common)				

FAILURE FREQUENCY FOR VARIOUS EQUIPMENT

Remark : ILO (International Labor Organization, Major Hazard Control), 1998
Incedent	Frequency (times/yr)	Propability of occurrence
Less, 1	983; King ,1990	
Pressure vessels (general)	0.026	1 (unlikely)
Pressure vessels (high standard)	2.56×10⁻³	1 (unlikely)
Pipes	1.71×10 ⁻³	1 (unlikely)
Pipe joints	4.27×10 ⁻³	1 (unlikely)
Gaskets	4.27×10 ⁻³	1 (unlikely)
Bellows	0.043	1 (unlikely)
Diaphragms (metal)	0.043	1 (unlikely)
Diaphragms (rubber)	0.068	1 (unlikely)
Unions	3.42×10 ⁻³	1 (unlikely)
Hoses (heavily stressed)	0.342	1 (unlikely)
Hoses (lightly stressed)	0.0342	1 (unlikely)
Relief valves (leakage)	0.017	1 (unlikely)
Relief valves (blockage)	4.27×10 ⁻³	1 (unlikely)
Valves (hand-operated)	0.128	2 (reasonably likely)
Valves (ball)	4.27×10 ⁻³	1 (unlikely)
Seals (rotating)	0.0598	1 (unlikely)
Seals (sliding)	0.0256	1 (unlikely)
Seals ("o" ring)	1.708×10 ⁻³	1 (unlikely)
Filters (blockage)	8.544×10 ⁻³	1 (unlikely)
Filters (leakage)	8.544×10 ⁻³	1 (unlikely)
Pins	0.128	2 (reasonably likely)
Nuts	1.708×10 ⁻³	1 (unlikely)
Bolts	1.708×10 ⁻³	1 (unlikely)
Boiler (all types)	9.398×10 ⁻³	1 (unlikely)
Pressure-indicating controller	1.15	4 (common)
Pressure-recovery controller	1.29	4 (common)
Flow-indicating controller	1.51	4 (common)
Flow-recording controller	2.14	4 (common)
Level-indicating controller	2.37	4 (common)
Level-recording controller	2.25	4 (common)
Temperature-indicating controller	0.94	3 (likely)
Temperature-recording controller Trip initiator	1.99	4 (common)

FAILURE FREQUENCY FOR VARIOUS EQUIPMENT (Cont'd)

Remark : ILO (International Labor Organization, Major Hazard Control), 1998

PROBABILITY OF EQUIPMENT FAILURE OCCURRENCE

Equipment	Failure occurrence	Failure reate	Propability of
			Occurrence
Batteries	No output	3×10 ⁻⁶ times/hr	1 (unlikely)
Power supplies			
Circuit breakers	Failure to operate	1×10 ⁻³ times/hr	4 (common)
	Premature transfer	1×10 ⁻⁶ times/hr	1 (unlikely)
Diesel (complete plant)	Failure to start	3×10 ⁻² times/day	4 (common)
(emergency loads)	Failure to run	3×10 ⁻³ times/hr	4 (common)
Diesel (engine only)	Failure to run	3×10 ⁻⁴ times/hr	4 (common)
Electric Motors	Failure to start	3×10 ⁻⁴ times/day	2 (reasonably likely)
	Failure to run	1×10 ⁻⁵ times/day	1 (unlikely)
	Failure to run-extreme	1×10 ⁻³ times/hr	4 (common)
	environment		
Fuses	Premature, open	1×10 ⁻⁶ times/hr	1 (unlikely)
	Failure to open	1×10 ⁻⁵ times/hr	1 (unlikely)
Gaskets	Leak	3×10 ⁻⁶ times/hr	1 (unlikely)
Flanges, Closures, Elbows	Leak/rupture	3×10 ⁻⁷ times/hr	1 (unlikely)
Instrumentation(amplification,	Failure to operate	1×10 ⁻⁶ times/hr	1 (unlikely)
annunciators,			
transducers, calibration,	Shifts	3×10 ⁻⁵ times/hr	3 (likely)
combination)			
Pipe >3", high quality	Rupture (section)	1×10 ⁻¹⁰ times/hr	1 (unlikely)
Pipes <3"	Rupture	1×10 ⁻⁹ times/hr	1 (unlikely)
Pumps	Failure to start	1×10 ⁻³ times/day	3 (likely)
	Failure to run-normal	3×10 ⁻⁵ times/hr	3 (likely)
	Failure to run-extreme	1×10 ⁻³ times/hr	4 (common)
	environment		
Relays	Failure to energize	1×10 ⁻⁴ times/day	1 (unlikely)
	Failure-no contact to close	3×10 ⁻⁷ times/hr	1 (unlikely)
	Short Across NO/NC contact	1×10 ⁻⁸ times/hr	1 (unlikely)
	Open NC contact	1×10 ⁻⁷ times/hr	1 (unlikely)
Solid State Devices	Fails to function	3×10 ⁻⁶ times/hr	1 (unlikely)
	Shorts	1×10 ⁻⁶ times/hr	1 (unlikely)
Hi Power Application	Fails to function	1×10 ⁻⁶ times/hr	1 (unlikely)
Low Power Application	Short	1×10 ⁻⁷ times/hr	1 (unlikely)
Switches	Limit: fail to operate	3×10 ⁻⁴ times/day	2 (reasonably likely)

PROBABILITY OF EQUIPMENT FAILUF	RE OCCURRENCE (Cont'd)
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Equipment	Failure occurrence	Epilure rate	Propability of
Equipment			occurrence
Switches	Limit: fail to operate	3×10 ⁻⁴ times/day	2 (reasonably likely)
	Torque: fail to operate	1×10 ⁻⁴ times/day	1 (unlikely)
	Pressure: fail to operate	1×10 ⁻⁴ times/day	1 (unlikely)
	Manual: fail to operate	1×10 ⁻⁴ times/day	1 (unlikely)
	Manual: contacts short	1×10 ⁻⁸ times/hr	1 (unlikely)
Transformers	Open	1×10 ⁻⁶ times/hr	1 (unlikely)
	Short	1×10 ⁻⁶ times/hr	1 (unlikely)
Manually operated valve	Fails to operate (plug)	1×10 ⁻³ times/day	3 (likely)
	Failure to remain open	1×10 ⁻⁴ times/day	1 (unlikely)
	External leak-rupture	1×10 ⁻⁸ times/hr	1 (unlikely)
Solenoid operated valve	Fails to operate	1×10 ⁻³ times/day	3 (likely)
Air operated valve	Fails to operate	3×10 ⁻⁴ times/day	4 (common)
	Failure to remain open	1×10 ⁻⁴ times/day	3 (likely)
	External leak-rupture	1×10 ⁻⁸ times/hr	1 (unlikely)
Check valve	Failure to open	1×10 ⁻⁴ times/day	1 (unlikely)
	Reverse to remain open	1×10 ⁻⁷ times/hr	1 (unlikely)
	External leak-rupture	1×10 ⁻⁸ times/hr	1 (unlikely)
Vacuum valve	Fails to operate	3×10⁻⁵ times/day	1 (unlikely)
	Rupture	1×10 ⁻⁸ times/hr	1 (unlikely)
Valve: orifices, flow, meters,	Rupture	1×10 ⁻⁸ times/hr	1 (unlikely)
(test)			
Valves (relief)	Failure to open	1×10 ⁻⁵ times/day	1 (unlikely)
	Premature open	1×10 ⁻⁵ times/hr	1 (unlikely)
Weld	Leak	3×10 ⁻⁹ times/hr	1 (unlikely)

Source: Cryogenic and Oxygen Deficiency Hazard Safety: ODH Risk Assessment Procedures, 27 Feb 2006 (update 13 Feb 2009) SLAC-1-730-0A06C-001-R001.

As shown in **Table 5.1.4.6-26**, the failure rates, which are the numbers of times the failures occur in a year are as follows:

- Failure caused by an individual 1×10⁻³ times/yr
- Failure due to the safety valve 0.02 times/yr
- Failure due to the steam boiler 9.3981×10⁻³ times/yr
- Failure due to the pressure indication controller 1.15 times/yr
- Failure due to the relay 0.08 times/yr
- Failure due to the temperature sensor 0.94 times/yr
- Failure due to the water gauge 8.2×10⁻⁶ times/yr
- Failure due to power outage 10 times/yr
- Failure due to the nuts, bolts, or seals 1.708×10⁻³ times/yr

As shown in **Table 5.5.6-27**, the failure rates, which are the numbers of times the failures occur in a year are as follows:

- Failure due to malfunction of the pump 0.026 times/yr
- Failure due to steam turbine governor 0.0026 times/yr
- Instrument failure 0.0087 times/yr

The risk or of failure probability due to the equipment mentioned above is evaluated in accordance with the criteria and results stipulated in the Regulations of Department of Industrial Works on criteria in hazard identification, risk assessment, and formulation of risk management plans B.E.2543. Four levels of failure probability are defined, as follows:

Level	Definition
1	Rare probability of occurrence i.e. never in more than 10 yr
2	Low probability of occurrence i.e. once in 5-10 yr
3	Moderate probability of occurrence i.e. once in 1-5 yr
4	High probability of occurrence i.e. more than once in a year

The levels of risk or failure probability due to the equipment aforementioned

above are shown in Table 5.1.4.6-26 and Table 5.1.4.6-27.

•	Failure caused by an individual	propability of occurrence = 1
•	Failure due to the safety valve	propability of occurrence = 1
•	Failure due to the steam boiler	propability of occurrence = 1
•	Failure due to the pressure-indicating	
	controller	propability of occurrence = 1
٠	Failure due to the relay	propability of occurrence = 1
•	Failure due to the relay Failure due to the temperature sensor	propability of occurrence = 1 propability of occurrence = 1

- Failure due to the nuts, bolts, or seals propability of occurrence = 1
- Failure due to malfunction of the pump propability of occurrence = 1
- Failure due to steam turbine governor propability of occurrence = 1
- Instrument failure
- propability of occurrence = 1

For failure due to power outage, the level of failure probability is 1, for there is emergency generator in the project.

(4) Results of risk assessment

From the analysis of the causes of possible failures which can consequently incur major hazards, the results as well as relevant preventive measures are summarized as follows:

• Explosion of the gas turbine

Because the results of the risk assessment of explosion of the gas turbine, which can occur due to several causes as shown in **Table 5.1.4.6-28**, reveal different risk levels; the higher risk level is chosen for the assessment. The risk of gas turbine explosion is thus at the level of 2, which is regarded as an acceptable risk. However, revision of the preventive measures is required as follows:

- Check-up of the gas detector of the gas turbine is to be conducted regularly.

- Check-up and maintenance of the purge system of the gas turbine are to be conducted according to schedule.

- Check-up and maintenance of the gas distribution control system of the gas turbine are to be conducted according to schedule.

- Check-up of the operation of the temperature sensor of the gas turbine is to be conducted regularly.

- Check-up of the controller of the gas turbine is to be conducted regularly to ensure its operational consistency.

- Check-up and maintenance of the control equipment of the gas turbine are to be conducted according to schedule.

- Equipment and control system to be used must have been approved in accordance with international standards.

• Explosion of the steam turbine

Because the results of the risk assessment of explosion of the steam turbine, which can occur due to several causes as shown in **Table 5.5.6-29**, reveal different risk levels; the higher risk level is chosen for the assessment. The risk of steam turbine explosion is thus at the level of 2, which is regarded as an acceptable risk. However, revision of the preventive measures is required as follows:

|--|

CAUSES OF THE EVENTS LEADING TO POSSIBLE GAS TURBINE EXPLOSION, AND THE COUNTERMEASURES

Causes of the events leading to	Hazards or			Risk a	ssessment	
major hazards	subsequent events	Preventive and control measures	Likelihood	Severity	Consequence	Risk level
In the case of operational failures						
Residual gas left during startup						
• Damage to the pressure indication controller	 Gas turbine explosion 	• Check-up of the gas detector of the gas turbine to be conducted regularly	1	4	4	2
Damage to the gas flushing system	Gas turbine explosion	• Check-up and maintenance of the gas flushing system of the gas turbine to be conducted according to schedule	1	4	4	2
Too high temperature						
Damage to the shut off valve	 Gas turbine explosion 	 Check-up and maintenance of the gas distribution control system of the gas turbine to be conducted according to schedule 	1	4	4	2
Damage to the temperature sensor	 No alarm from the controller 	• Check-up of the operation of the temperature sensor of the gas turbine to be conducted regularly	3	1	3	2
• Malfunction of the alarm receiver	 No alarm from the controller 	• Check-up of the controller of the gas turbine to be conducted regularly to ensure its operational consistency	1	1	1	1
System incoherence						
Damage to the control equipment	 Gas turbine explosion 	• Check-up and maintenance of the control equipment of the gas turbine to be conducted according to schedule	1	4	4	2
• Failure in the control system	Gas turbine explosion	 Equipment and control system to be used having been approved in accordance with international standards 	1	4	4	2

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CAUSES OF THE EVENTS LEADING TO POSSIBLE STEAM TURBINE EXPLOSION, AND THE COUNTERMEASURES

Causes of the events leading to	Hazards or			Risk a	ssessment	
major hazards	subsequent events	Preventive and control measures	likelihood	severity	consequence	Risk level
In the case of operational failures						
Steam turbine overload						
Malfunction of the safety valve	Steam turbine explosion	 Check-up of the condition of the safety valve to be conducted regularly 	1	4	4	2
 The pressure not checked by the staff 	Rise in steam pressure	 Training to be provided regularly in order that the staff can perform their work properly 	1	4	4	2
 Malfunction of the pressure indication controller 	Constant steam distribution	Check-up of the pressure indication controller to be conducted regularly	3	1	3	2
System power failure	No alarm from the controller	 Check-up of emergency generator to be conducted regularly 	1	1	1	1
Malfunction of the alarm receiver	No alarm from the controller	Check-up of the controller of the steam turbine to be conducted regularly to ensure its operational consistency	1	1	1	1
In the case of safety equipment						
 Malfunction of the safety valve 	Steam turbine explosion	Check-up of the condition of the safety valve to be conducted regularly	1	4	4	2
 Malfunction of the pressure indication controller 	Steam turbine explosion	Training to be provided regularly in order that the staff can perform their work properly	1	4	4	2
 No check-up of the pressure indication controller by the staff 	Steam turbine explosion	 Training to be provided regularly in order that the staff can perform their work properly Experts to be on duty all the time the system is on 	1	4	4	2
Malfunction of the steam turbine governor	Steam turbine explosion	 Check-up of the condition of the steam turbine governor is to be conducted regularly 	1	4	4	2
 Malfunction of the component equipment in the steam turbine governing system 	Steam turbine explosion	Training to be provided regularly in order that the staff can perform their work properly	1	4	4	2
No check-up of the component equipment in the steam turbine governing system by the staff	Steam turbine explosion	 Training to be provided regularly in order that the staff can perform their work properly Experts to be on duty all the time the system is on 	1	4	4	2

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- Check-up of the condition of the safety valve is to be conducted regularly.

- The rupture disc is to be installed for the steam turbine as a safety measure in case the pressure exceeds the limit.

- Training is to be provided regularly in order that the staff can perform their work properly.

- Check-up of the condition of the steam turbine governor is to be conducted regularly.

- Check-up of the pressure indication controller is to be conducted regularly.

- Check-up of emergency generator is to be conducted regularly.

- Check-up of the controller of the steam turbine is to be conducted regularly to ensure its operational consistency.

- Experts are to be on duty all the time the system is on.

• Explosion of the steam boiler

Because the results of the risk assessment of explosion of the steam boiler, which can occur due to several causes as shown in **Table 5.1.4.6-30**, reveal different risk levels; the higher risk level is chosen for the assessment. The risk of the steam boiler explosion is thus at the level of 2, which is regarded as an acceptable risk. However, revision of the preventive measures is required as follows:

- Check-up of the condition of the safety valve is to be conducted regularly.

- The safety valve of the steam boiler must meet the standards set by the American Society of Mechanical Engineers – ASME (Section 1- Power Boiler), and those by the Department of Industrial Works.

- Training is to be provided regularly in order that the staff can perform their work properly.

- Check-up of the pressure indication controller is to be conducted regularly.

- Check-up of emergency generator is to be conducted regularly.

- Check-up of the controller of the steam boiler is to be conducted regularly to ensure its operational consistency.

- Check-up of the condition of the water pump is to be conducted regularly.

- There must be a water pump in reserve for the steam boiler.

Chapter 5

Causes of the events leading to major	Hazards or			Risk as	sessment	
hazards	subsequent events	Preventive and control measures	Likelihood	Severity	Consequence	Risk level
In the case of operational failures						
Steam boiler overload						
• Malfunction of the safety valve	Steam boiler explosion	 Check-up of the condition of the safety valve to be conducted regularly The safety valve of the steam boiler must meet the standards set by ASME (Section 1- Power boiler), and those by the Department of Industrial Works. 	1	4	4	2
• The pressure not checked by the staff	Rise in steam pressure	 Training to be provided regularly in order that the staff can perform their work properly 	1	1	1	1
Malfunction of the pressure indication controller	Constant fuel feed	Check-up of the pressure indication controller to be conducted regularly	3	1	3	2
System power failure	No alarm from the controller	Check-up of emergency generator to be conducted regularly	1	1	1	1
Malfunction of the pressure indication controller	No alarm from the controller	• Check-up of the controller to be conducted regularly to ensure its operational consistency	3	1	3	2
Water supply system failures						
• Boiler leak	 Steam boiler explosion 	Check-up of the condition of the steam boiler to be conducted regularly.	1	4	4	2
Malfunction of the water pump	 Steam boiler explosion 	 Check-up of the condition of the water pump to be conducted regularly. There must be a water pump in reserve for the steam boiler. In case of malfunction of the water pump, the system to be off until the repair is done. 	1	4	4	2

CALISES OF THE EVENTS LEADING TO POSSIBLE STEAM BOILER EXPLOSION AND THE COLINTERMEASURES

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Chapter 5 Anticipated Environmental Impacts and Mitigations

Causes of the events leading to	Hazards or		Risk assessment					
major hazards	subsequent events	Preventive and control measures	Likelihood Severity		Consequence	e Risk leve		
In the case of operational failures (Cont'd)								
The water system not regulated by the staff then	 Steam boiler explosion 	• Training to be provided regularly in order that the staff can perform their work properly	1	4	4	2		
Malfunction of the water gauge	Steam boiler explosion	• Check-up of the water gauge to be conducted regularly to ensure its operational consistency	1	4	4	2		
The water gauge not checked by the staff	Steam boiler explosion	 Training to be provided regularly in order that the staff can perform their work properly 	1	4	4	2		
 Inappropriate water quality 	Steam boiler explosion	 Training to be provided regularly in order that the staff can perform their work properly Experts to be on duty all the time the steam boiler system is on. 	1	4	4	2		
 No check-up by the staff according to schedule 	Steam boiler explosion	 Training to be provided regularly in order that the staff can perform their work properly 	1	4	4	2		
In the case of safety equipment failures								
• Malfunction of the safety valve	Steam boiler explosion	 Check-up of the condition of the safety valve to be conducted regularly two sets of safety valves on hand – one set in reserve 	1	4	4	2		
Malfunction of the water gauge	Steam boiler explosion	 Training to be provided regularly in order that the staff can perform their work properly 	1	4	4	2		
 The water gauge not checked by the staff 	• Steam boiler explosion	 Training to be provided regularly in order that the staff can perform their work properly Experts to be on duty all the time when the system is on 	1	4	4	2		

- In case of malfunction of the water pump, the system is to be off until the repair is done.

- Check-up of the water gauge is to be conducted regularly to ensure its operational consistency.

- Experts are to be on duty all the time the system is on.

- The scale condition is to be checked regularly.

• explosion of the electricity generator

Because the results of the risk assessment of explosion of the electricity generator, which can occur due to several causes as shown in **Table 5.1.4.6-31**, reveal different risk levels; the higher risk level is chosen for the assessment. The risk of the electricity generator explosion is thus at the level of 2, which is regarded as an acceptable risk. However, revision of the preventive measures is required as follows:

- The operation of the overcurrent protection relay system must be checked to ensure that the current is in the preset limit.

- Check-up of the temperature sensing coil is to be conducted regularly.

- The temperature controller must be checked to ensure that it the temperature is in the predetermined limit.

- The sensor in reserve must be checked to ensure its ready-for-use condition.

- Procedures concerning the operation of electrical equipment are to be clearly delineated.

- The condition is to be established that electricity from different generators is not to be combined unless first synchronized.

- The synchronized system and the interlock system must be checked to ensure its operational consistency.

- The operation of the protection equipment for example the overcurrent protection relay, voltage relay for leakage protection, and other types of relays, must be checked.

- Check-up of the protection system in power system is to be scheduled in the annual maintenance plan and also at a regular basis to ensure that all the electric equipment in the protection system functions properly.

CAUSES OF THE EVENTS LEADING TO POSSIBLE ELECTRICITY GENERATOR EXPLOSION, AND THE COUNTERMEASURES

Environmental Report for submittal to ADB

Chapter 5

Causes of the events	the events			Risk assessment			
leading to major hazards	Hazards or subsequent events	Preventive and control measures	Likelihood	Severity	Consequence	Risk leve	
In the case of operational failures							
Electricity generator							
Malfunction of the overcurrent protection relay system	 Explosion resulting from the coil burning and the consequent short circuit 	 The operation of the overcurrent protection relay system must be checked to ensure that the current is in the preset limit. 	1	4	4	2	
The meter not checked by the staff	Overcurrent	 Training to be provided regularly in order that the staff can perform their work properly 	1	1	1	1	
Malfunction of the temperature sensing coil	 Temperature of the coil higher than the predetermined limit, thus the relay system not opening the circuit The coil overheating, resulting in the insulator burning and explosion 	 Check-up of the temperature sensing coil to be conducted regularly The temperature controller must be checked to ensure that it the temperature is in the predetermined limit The sensor in reserve must be checked to ensure its ready-for-use condition 	1	4	4	2	
n the case of operation control system failures							
While the system is on and when electricity is supplied from outside Failure of the interlock system	Explosion at the controllerExplosion at the electricity generator	 Procedures concerning the operation of electrical equipment to be clearly delineated. The condition to be established that electricity from different generators is not to be combined unless first synchronized. The synchronized system and the interlock system must be checked to ensure its operational consistency. 	1	4	4	2	

CAUSES OF THE EVENTS LEADING TO POSSIBLE ELECTRICITY GENERATOR EXPLOSION, AND THE COUNTERMEASURES (Cont'd)

TABLE 5.1.4.6-31

Causes of the events	Hazards or subsequent events	Preventive and control measures	Risk assessment			
leading to major hazards			Likelihood	Severity	Consequence	Risk level
In the case of electric						
fault in the system						
• Damage to the	• Violent short circuit at the	• Training to be provided regularly in order that the	1	4	4	2
transformer	power box resulting in the	staff have good understanding concerning the				
• Fault in the electricity	explosion of both the power	functions of the equipment				
supply system and	box and the electricity	• The operation of the protection equipment for				
malfunction of the	generator	example the overcurrent protection relay, voltage				
prevention system		relay for leakage protection, and other types of				
• Malfunction of the		relays must be checked.				
prevention system		• Check-up of the protection system in power system				
		to be scheduled in the annual maintenance plan				
		and also at a regular basis to ensure that all the				
		electric equipment in the protection system				
		functions properly.				

Chapter 5

5.5.7 Summary of the major hazard assessment

The study reveals that in case of accidental release of natural gas/diesel which results in ignition, the radius of the heat radiation is mostly within the compound of the power plant in the project. Furthermore, from the risk probability analysis, the project's risk level is considered low. Hence, probability of major hazards owing to this cause is very low.

With respect to hazards from chemical substances and explosion of equipment and machinery, with reference to the hazard analysis conducted in accordance with the Department of Industrial Works' guideline, probability of the hazards is found to be at a low and acceptable level. In addition, for utmost safety, measures on safety management have been developed for the project encompassing the design, installation, operational and annual inspection phases.

Mitigation Measures

(1) Construction Period

• Designate the areas for welding of natural gas and diesel oil pipelines as "restricted areas", in which working related to heat and sparking is prohibited. Signs of danger warning will be places around the areas. In case it is necessary to work in the areas, permit must be obtained before accessing the areas.

• Fence the welding areas and put danger warning signs, including establishment of work permit system.

• Before construction, the contractor must prepare and submit occupational health and safety action plan to Gulf SRC Co., Ltd., to approve and control implementation as planned.

• Provision of sufficient personal protection equipments, suitable for nature of work to staffs.

• Provision of security guards to watch and examine working, including to control the wearing of personal protection equipments suitable for nature of work, as necessary.

• Provision of suitable numbers of portable chemical fire extinguishers and place them in the construction areas that may have firing.

• Provision of first aid equipments and Shuttle Emergency in construction

areas. as required by the Ministry of Labor's Regulations Welfare in Workplace (B.E 2548).

• Placing warning signs in the risk areas. No permission to work

long in this area, if no personal protection equipments.

• Coordinate with hospitals close to the project site for the case of emergency.

(2) Operation Periods

Preventative Measures of the System of Natural Gas Pipeline and the Diesel Pipelines in the project area.

• Designate natural gas control stations as "restricted areas", in which working related to heat and sparking is prohibited by putting signs of danger warning around natural gas control stations and diesel oil tank areas. In case it is necessary to work in the areas, checking and controlling must be strict and work permit system must be conducted.

• Maintenance natural gas and diesel oil pipeline systems together with equipments to be ready for working and to keep watching for safety.

• Check the thickness of the gas pipeline route and the level of erosion of pipelines, regularly.

• Conduct leakage survey of natural gas and diesel oil pipeline systems in accordance with related standards

• Mark hazard zone and establish control and prevention measure for safety e.g. No Smoking Zone, Hot Work Zone, where access permission is required, etc.

• Inspect the leakage of the natural gas, using the gas measurement equipment to detect the main leakage above the ground at the MRS regularly as specified in the Safety Procedure.

• Install warning signs along the pipeline route with warning to prevent any action in the area above the pipeline route which may affect the pipeline and so that people finding abnormalities may report to the person in charge.

• Establish and enforce the regulation and methods of work for the safety of work concerning natural gas pipeline.

• Configure the system of control of the shutdown and a system of relief valves to enable detection of abnormalities of the pressures within the pipeline correctly and promptly.

• Diesel oil tanks must be surrounded by concrete dike, which can carry 110% of the biggest tank capacity in case of broken or leak, according to the ministerial law on oil storage regulation, B.E.2551 (2008) of Ministry of Energy.

• The area of the station for unloading of the truck's oils must have dikes surrounding it so that the rain can flow through and clean up the oil stains which may have spilt or leaked in the area into the waste water collection pipe to be sent to the Oil Separator.

Control and Monitoring Measures

Establish hazard zones where persons entering the hazard zone must strictly follow the control and preventive measures for the safety such as:

• Prohibit Smoking

• Prohibit bringing cigarette lighters, matches or anything that may cause spark into the hazard zone established.

• Prohibit bringing or storing flammable substance in the hazard

zone.

- Prohibit bringing or storing self- combustion substance, such as the yellow phosphorus, the white phosphorus, and Magnesium Alloys, etc.
- Work with heat, such as, welding, metal cutting, etc. must obtain prior permission from the authoritative person.
 - Safety measures must be in place before work starts.
 - Prohibit persons without related function to the work to enter the

hazard zone.

Plan for Prevention and Suppression Emergency and Fire from

Natural Gas

- 1. Objectives
 - Prevent fire from Natural Gas
 - Be prepared for and to take appropriate action in case of fire.
- 2. The essential fundamental information

To ensure safety in working with natural gas, we must know

about the characteristics that may cause danger from natural gas and the general method to deal with them, as follow:

• Fundamental property and property which may cause danger from natural gas.

- The natural gas being used by the power generation unit is mainly Methane gas known as Dry Gas.

- It is a natural gas having vapor density equal to 0.6 when comparing with the air by weight (the air being equal to 1).

- Methane gas is in the form of vapor at the normal temperature and pressure.

- Liquid Methane gas can expand many times in the form of vapor when comparing with other gases.

- Flammable and Explosive Limit of Methane is between 5.0 to 14% (Low to High Limit).

• Danger from using natural gas

- It can flow and emit through the atmosphere (methane gas is hazard when mix with suitable level of air)

- Natural gas is colorless harmless to the body but if entered into the gas mass, a person can lose consciousness and short of breathing air.

• Action in case of Gas Leakage

- Approaching to or coming near the fire or the position of gas leakage must be from the upwind direction.

- Make everyone leave the area which the gas mass float through. Get rid of things that may ignite the gas and this must be done immediately.

- Assign persons to station at the area of gas leakage to prohibit people from coming near the area within 200 ft from gas leakage, except for persons needing to enter to carry out their duties.

Gas leaked but not ignited

- : Shut the Valves to stop the flow of gas.
- : Spray water in fine sprinkles to reduce gas vapor in the cross directions to the direction which the gas emerges or other direction to a safe direction.
- : If the leakage or the gas mass cannot be put out, measures must be taken to control combustion by

spraying large quantity of water to the hot metal parts, e.g. the pipe or the hot metal surface.

: Avoid the sources that may cause fire

Gas leaked and ignited

- : Shut the Valve to stop the flow of gas.
- : Prohibit the use of fire extinguishers until the gas leakage is stopped.
- : Spray water to the extreme hot area such as concrete, pipe, metal surface and allow the fire to burn at the draining pipe.
- : If there is a combustion at the valve that is the key to stopping the gas leakage, spray water with fine sprinkles and get someone wearing a fire protection suit to shut the valve.
- : Dry chemical can be used to extinguish minor gas fire by spraying directly at the point of gas leakage. Use CO₂ to extinguish fire for gas which has very low pressure.
- : If the gas leakage cannot be controlled, control the gas vapor bursting out by spraying water to protect equipment around the area of leakage.
- Prevention of Danger in case of Gas Leakage
 - : Upon occurrence of gas leakage, stop using all electrical equipment that are not explosion proof type in the area of leakage.
 - : Shut the valves to stop the flow of gas.
 - : Control the sources that may cause combustion, e.g. flame, hot surface spark, etc.
 - : Inspect the proportion of gas and air at the point of leakage to find the hazard points and to ventilate to expel the gas.

- : Persons working without the protective suit while functioning should inspect their own clothing because gas might have been trapped inside the clothing and may come be released later after the incident which may cause danger.
- Inspect to find the location of gas leakage
 - Determine point of measurement of quantity of gas leak
 - Prepare a table of inspection, specifying time of the inspection.
 - Carry out the inspection using gas inspection equipment.
- Repair or maintenance of equipment of pipelines which the

gas flows through.

- : Shut down or block off the section of equipment or pipe which the gas flows through before repairing.
- : Ventilate the air adequately in the area before working on the repair.
- : Inspect the proportion of gas and air before working and periodically while working on the repairing.
- : Use Non-Sparking Type equipment for repair.
- : Maintain equipment e.g. inspect facilities regularly and check thickness of the pipe which may be the point causing leakage, etc.
- Conduct annual emergency drill both in the part of the Power

Plant itself and the joint drill of emergency plan with Hemaraj Eastern Seaboard Industrial Estate and external agencies. Give training to personnel on the skill and expertise in relieving emergency, at least once a year.

Plan of Preparedness in Cases of Emergency from Oil Leak.

Follow the Measure on Unloading of Diesel, the Public Health Action Plan, the OHS Plan, during the operation phase.

CHAPTER 6

ANALYSIS OF ALTERNATIVES

The analysis of alternative has been conducted for the proposed power plant as follows:

(1) Criteria for Location Selection: The reasons for alternative consideration of the project implementation within Chon Buri and Rayong Provinces are mainly due to high electricity demand of the provinces and the target area located is in vicinity of Bangkok, the national economic centre. The advantages of such location for the provinces and for the entire nation are as follows:

- Majority of the Small Power Producers (SPP) are mostly located in the area of Industrial Estate or Industrial Park, where high electricity demand from industries in the area exists. Insufficient electricity in the Industrial area may cause black-out or electricity shortage which directly affects the industries, and local people.
- All of the Independent Power Producers (IPP) supply their electricity to EGAT to help maintaining national power stability.

In order to conduct the project implementation with least impacts on the environment and make feasible the design and investment, the consideration of project site location alternatives is an extremely important procedure. Meanwhile, the Office of the Natural Resources and Environmental Policy and Planning has specified the concept for studying alternative location of project site which is a process for initial screening for making decision to choose the most suitable location of the project area. However, the project implementation may cause direct impacts to environmental quality and any vulnerable environmental parameters such as air quality, water quality, and community etc., during construction and operation periods. Those impacts may result in concerns about wastewater quality and air quality. Thus, the project site location selection must be thoughtfully conducted to prevent and mitigate any impacts to community and its environment. In addition, the selected location must possess feasible engineering, construction and maintenance as well as appropriate investment. Accordingly, the criteria of the project location consideration are specified as follows:

- Mainly utilize the areas of the industrial parks to mitigate impacts on people's land use
- Avoid historic areas or archaeological sites
- Located in the areas with energy network or natural gas pipeline
- Have feasible engineering for both construction and maintenance
- Have enough basic infrastructure to support the need of the project
- Cause the least impact on sensitive environmental areas such as communities, religious places, schools, governmental offices and hospitals
- Avoid the areas specified in the attachment of the Notification of the Ministry of Natural Resources and Environment as specific conservative areas which have been protected by laws.

The project location selection has been conducted based on the above mentioned criteria. The selected project site is in the area of the Hemaraj ESIE which has been developed to support and facilitate industrial plants with provided basic infrastructure facilities.

Furthermore, the environmental impact assessment report of the Hemaraj ESIE was amended the project description and was approved by the Office of the Natural Resources and Environmental Policy and Planning as indicated in the official letter No. TorSor 1009.3/10241 dated August 26, 2015. Moreover, further consideration on other related issues can be summarized as follows:

- According to a consideration on laws of city planning and prescription on future land use of Chon Buri and Rayong Provinces, the project location is not included in the boundary of the Comprehensive Master Plan. In addition, the location of the project is within the area which has been specifically developed for industry. Hence, this mitigates any impacts on community and other areas.
- According to a consideration of areas with energy network or natural gas pipeline, the location of the project is near the natural gas pipeline of the Petroleum Authority of Thailand (PPT) Co., Ltd. (Public). Additionally, the project location is near the electricity transmission line of the Electricity Generating Authority of Thailand.

(2) Criteria for Fuel Selection: Natural gas is an extremely important source of energy in terms of reducing environmental pollution. Thus, the use of gas turbines and steam turbines are accepted as major source of electricity generation. Particularly high efficiencies can be achieved through combining gas turbines with a steam turbine in combined cycle mode. Natural gas burns cleaner than other fossil fuels, such as oil and coal, and produces less carbon dioxide per unit energy released. For an equivalent amount of heat, burning natural gas produces about 30% less carbon dioxide than burning petroleum and about 45% less than burning coal. Combined cycle power generation using natural gas is thus the cleanest source of power available using fossil fuels, and this technology is widely used wherever gas can be obtained at a reasonable cost.

(3) Criteria for Technology Selection: Combined cycle power plants use both gas and steam turbines to supply power to the network. A gas turbine generator generates electricity and the waste heat is used to produce steam to generate additional electricity through a steam turbine, which enhances the efficiency of electricity generation. Additionally, combined cycles are characterized by flexibility, quick part-load starting, suitability for both base-load and cyclic operation, and high efficiency over a wide range of loads.

(4) Criteria for Natural Gas Pipeline Route Selection: The study on alternative alignment of the natural gas pipeline to Sriracha Power Plant to link with the PPT pipeline was carried out by mean of preliminary survey in combination with investigation from aerial photograph of the area. The alignment must fulfill the objective of the Project development. Apart from this, the construction activities must have minimum effect to the environment and the local communities. The selection criteria are as follows:

- Avoid the local communities, or being as far as possible.
- Easy access and easy construction techniques.
- Utilize mainly on government land in order to minimize impact to

private land.

• Not in Historical area / archaeological site or antiquities.

• Not in conservation area according to the law and the Cabinet Resolutions; e.g. conservation forest and protected watershed, etc.

• The alignment should avoid passing through surface water source and road, to minimize impacts on utilization of those resources.

• The alignment should primary base on the existing transportation route, to benefit from the ROW of the road.

• The alignment should be as short as possible, and feasible in terms of both engineering and construction.

Avoid the risk area, and enforce strict safety standard.