Establishment of Port Air Pollutant Emissions Inventory

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July 12, 2011

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1. Introduction

- **Project Objectives**
  - Establishment of Port Air Pollutant Emissions Inventory
  - Draw up the action plan for port air cleaning and propose suggestions on port air pollutants management to reduce emissions
  - Investigate the experience of related strategies in the U.S. and apply those experiences to our project.
    - the Puget Sound Maritime Air Emissions Inventory
    - the San Pedro Bay Ports Clean Air Action Plan

1. Introduction

Scope of the Project

Establishment of Port Air Pollutant Emissions Inventory

- Build the Port Air Pollutant Emissions Inventory, which sets year 2009 as the baseline, and forecast the emission amount from 2010 to 2021 accordingly.
- The ports include Keelung Harbor, Taichung Harbor, Kaohsiung Harbor and Hualien Harbor (Next year to include Taipei Harbor).
- The categories of air pollutants include NO_X、VOC、CO、SO_2、PM_{10}、$PM_{2.5}$、DPM and the equivalent amount of GHG emissions.
- The emission sources include Ocean-going vessels, Harbor vessels, Rail locomotives, Cargo handling equipment, Heavy-duty vehicles, and Fugitive pollutant sources.

1. Introduction

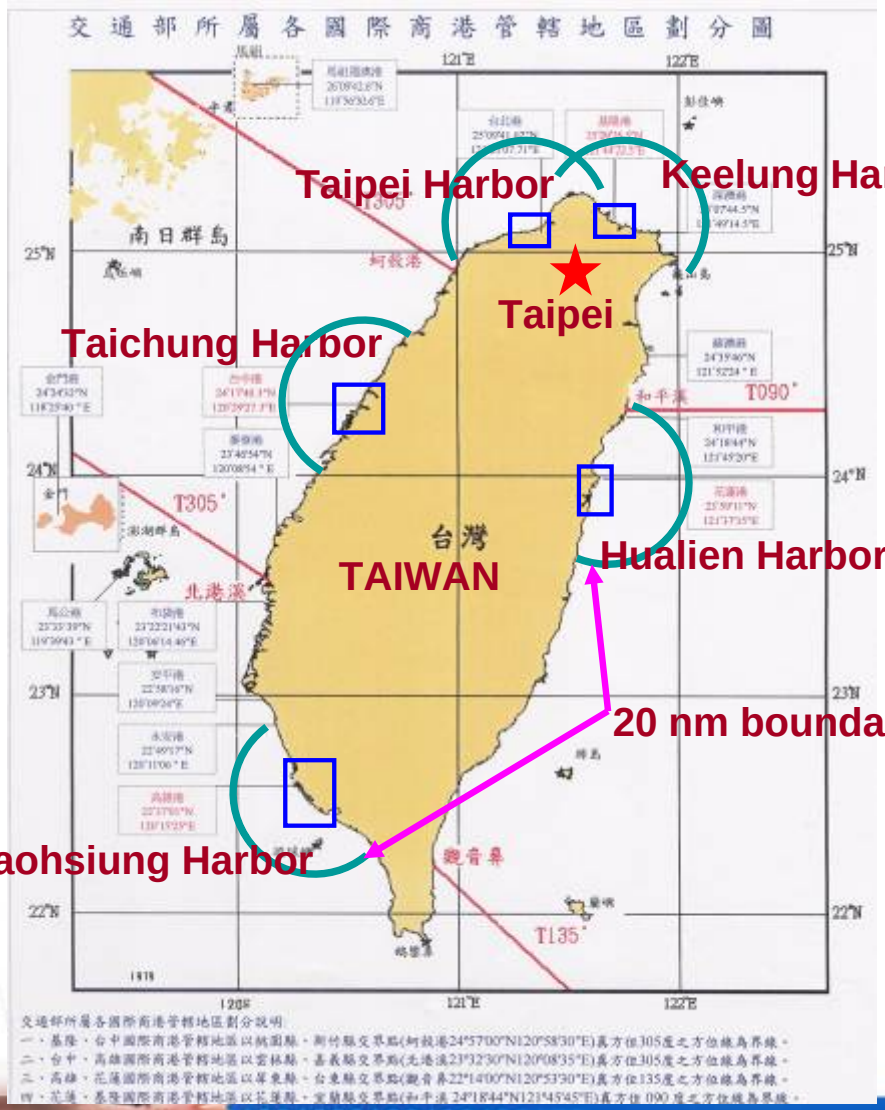
Scope of the Project

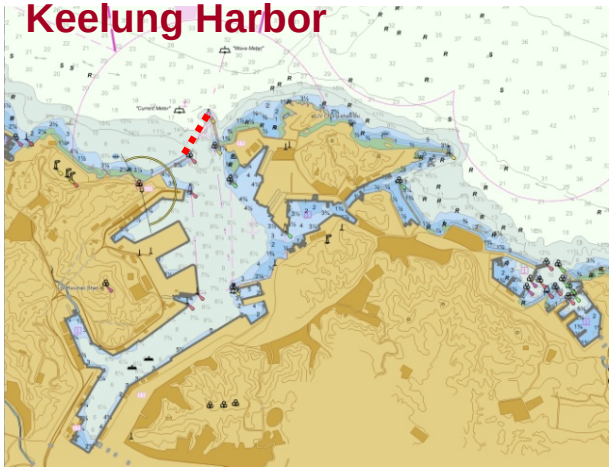
Draw up an action plan and propose suggestions on port air pollutant management to reduce emissions.

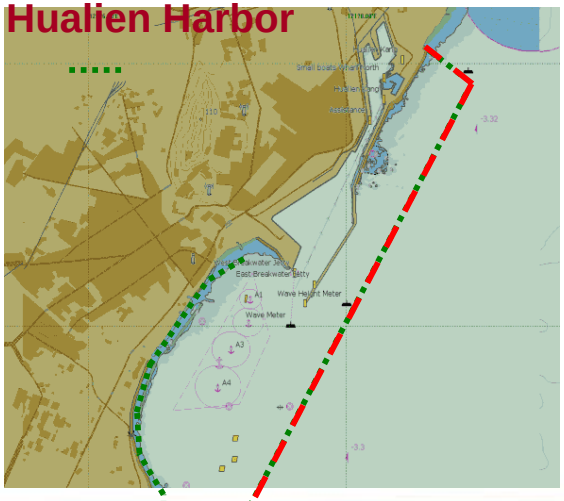
- Collect air pollutant management technologies and draft the best available control technologies (BACT) and the port air cleaning action plan.
- Hold conferences and invite related experts, organizations, port administrators, industry and environmental protection agencies to collect suggestions.
- Set up the communication channel with U.S. EPA.
- Analyze the correlation between port air pollutant emissions and the air pollution management strategies by using the emission inventories of this project, and propose future management strategies.
- Collect literature about the effect of sea/land breezes and vessel pollution on quality of air over land and conduct an integrated evaluation on Kaohsiung port as the evaluation subject.

2. Project Description

Locations of the Ports







2. Project Description

- Emission Estimate Methods
  - Emission Estimate for Base Year
    - Ocean-going Vessels, Harbor Crafts, Cargo Handling Equipment, Rail, Heavy Vehicles: adopt the methods used in Puget Sound Maritime Air Emissions Inventory, U.S.A., 2007, and other technical literature
    - Fugitive particles: adopt methods used by relevant studies in Taiwan
  - Emission Estimate from Year 2010 to 2021
    - Estimate based on the development plans for each harbor, predicted volume of freight handled and the control measures developed in this project

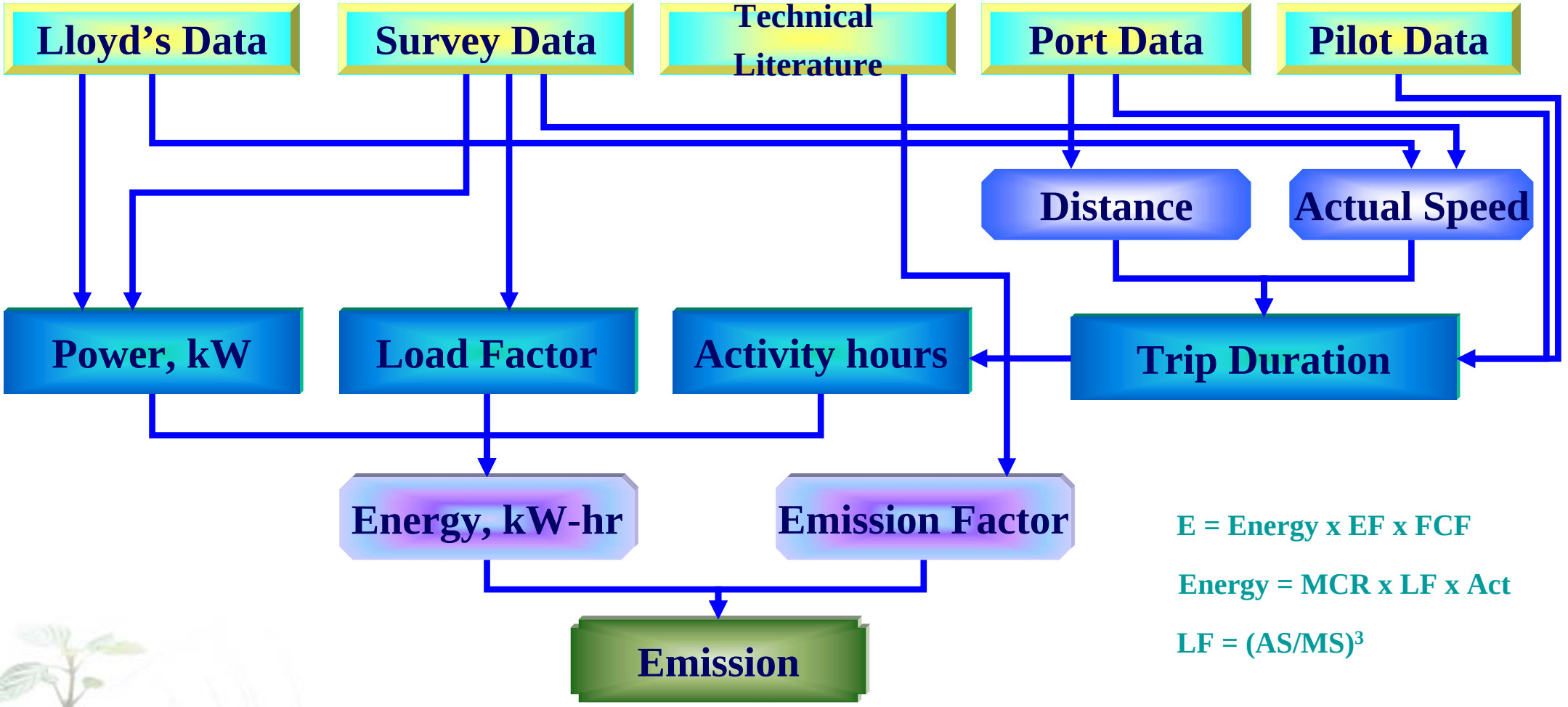
2. Project Description

Emission Estimate Methods

Sources	Geographical extent	Methods
Ocean-going Vessels	Port area and maritime area within 20 nm	Ship calls collected from each harbor bureau and ship data are consulted on Lloyd's ship register data. Emissions are then estimated as a function of vessel power demand multiplied by an emission factor.
Harbor Vessels	Port area and nearby maritime area	Harbor vessel data are collected from each harbor bureau. Annual hours of use in 2009 within each port area were used to calculated harbor vessel emissions.
Cargo Handling Equipment	Port area only	Cargo Handling Equipment data are collected from each harbor bureau and terminal operators. Emissions are estimated using the NONROAD model with modification for local parameters.
Rail Locomotives	Port area only	Locomotive operational data are collected from the railway administration. Emissions are estimated with power demand multiplied by an emission factor.
Heavy-duty Vehicles	Port area only	Vehicles and journey data are collected from each harbor bureau and terminal operators. Emission factors are estimated using the Mobile-Taiwan model.

2. Project Description

OGVs Emissions Estimation Flow Diagram



$E = Energy \times EF \times FCF$

$Energy = MCR \times LF \times Act$

$LF = (AS/MS)^3$

3. Current Results

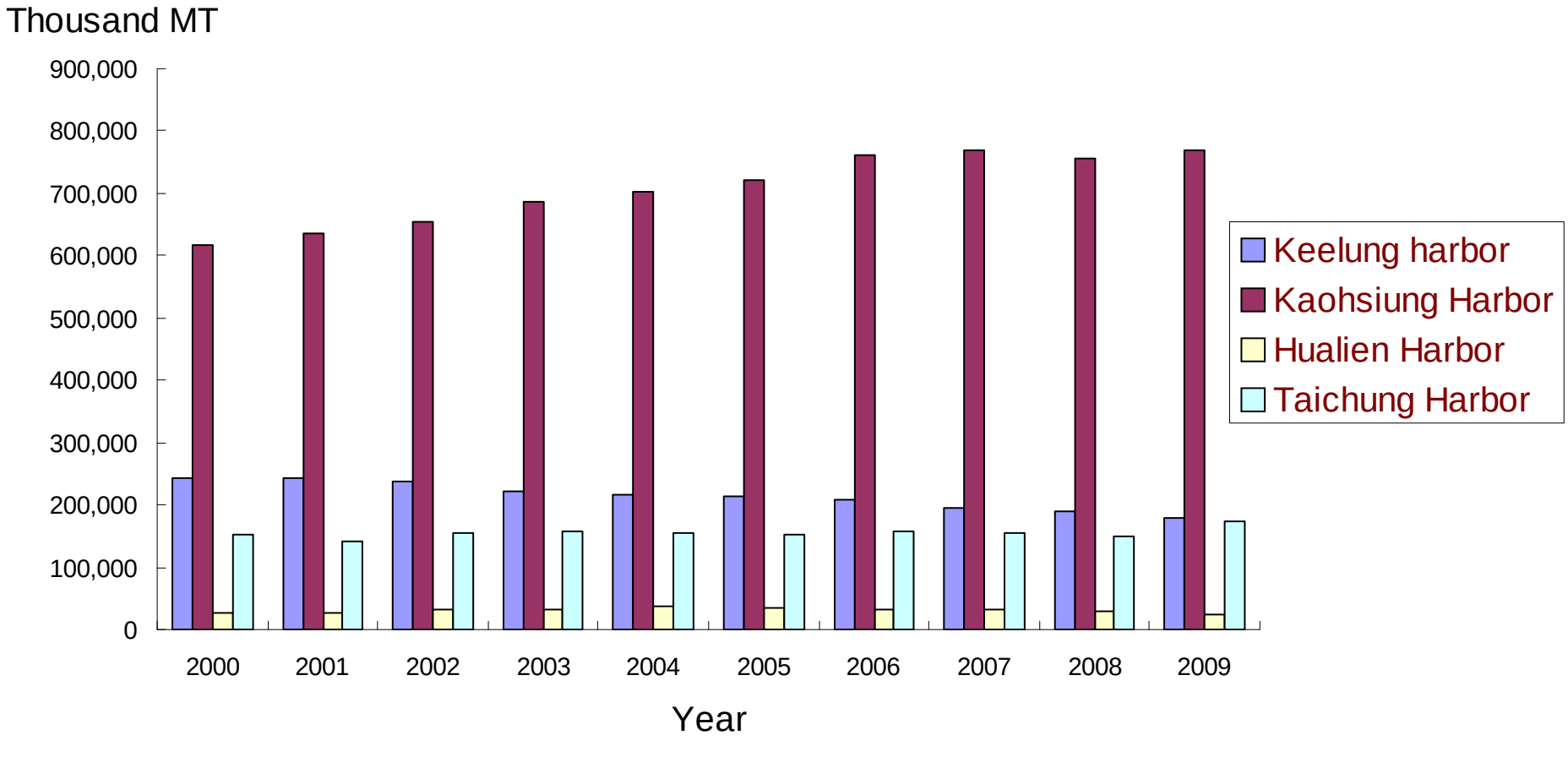
Statistics of 2009 OGV calls by vessel type

Unit: call

Vessel Type	Keelung Harbor	Kaohsiung Harbor	Hualien Harbor	Taichung Harbor
Passengers	153	125	3	42
Passengers & Cargoes	312	244	—	19
Containers	3,783	8,102	—	3,059
Reefer	3	130	—	—
Grains	2	26	—	50
Oil Tankers	227	2,631	40	553
Ore	6	37	—	4
Coal	1	150	2	114
Lumber	—	—	—	—
Bulk	1,337	1071	644	787
General Cargo	1,022	3,319	1,444	977
Other	177	1,694	103	701
Total	7,023	17,529	2,236	6,306

3. Current Results

- Volumes of freight handled for main international ports in Taiwan



Source: Ministry of Transportation and Communication, 2010

3. Current Results

Ports 2009 Air Emissions Inventory Summary

Unit: MT/Year

Port	Sources	NO_X	VOC	CO	SO_2	PM_{10}	$PM_{2.5}$	DPM	CO_{2EQ}
Keelung Harbor	Ocean-going vessels	3952.8	133.5	322.9	3263.5	258.2	203.3	192.1	246048.2
	Harbor vessels	76.7	1.7	15.2	13.0	1.9	1.7	1.9	4349.4
	Cargo handling equipment	11.5	0.8	2.8	0.0	0.5	0.5	0.5	1275.4
	Rail	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Heavy-duty vehicles	29.6	4.4	19.5	0.1	1.7	1.5	1.7	2059.8
	Total	**4070.6**	**140.3**	**360.4**	**3276.5**	**262.4**	**207.1**	**196.2**	**253732.7**
Taichung Harbor	Ocean-going vessels	2667.1	99.2	229.7	2800.1	202.7	157.9	118.3	215043.9
	Harbor vessels	95.0	2.7	30.7	20.9	3.0	2.8	3.0	6964.3
	Cargo Handling equipment	59.1	4.6	31.6	0.3	4.7	4.6	4.7	8493.4
	Rail	3.2	0.2	0.5	0.0	0.1	0.1	0.1	207.8
	Heavy-duty vehicles	322.1	50.9	207.5	0.6	18.4	16.2	18.4	23982.4
	Total	**3146.4**	**157.5**	**500.0**	**2821.9**	**228.9**	**181.6**	**144.6**	**254691.7**

3. Current Results

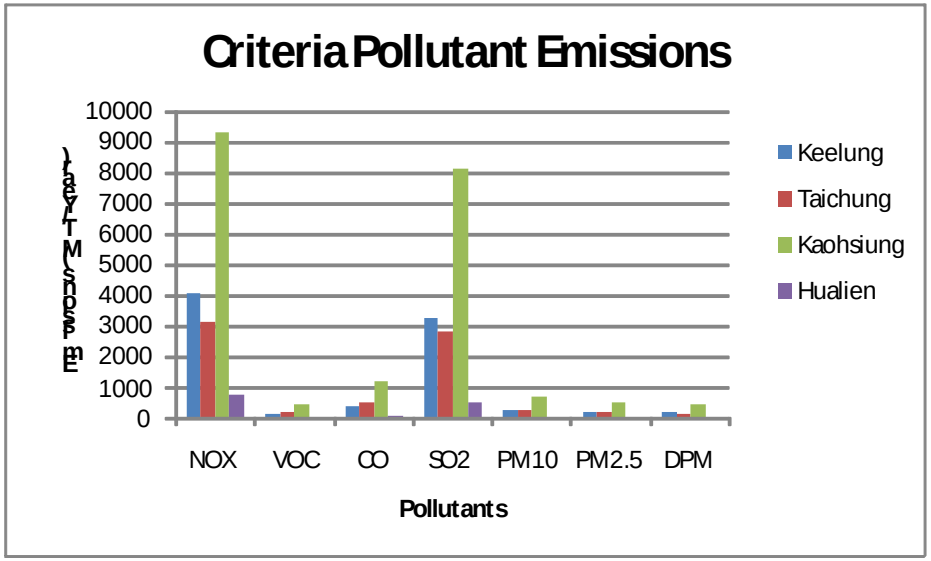
Ports 2009 Air Emissions Inventory Summary (continued)

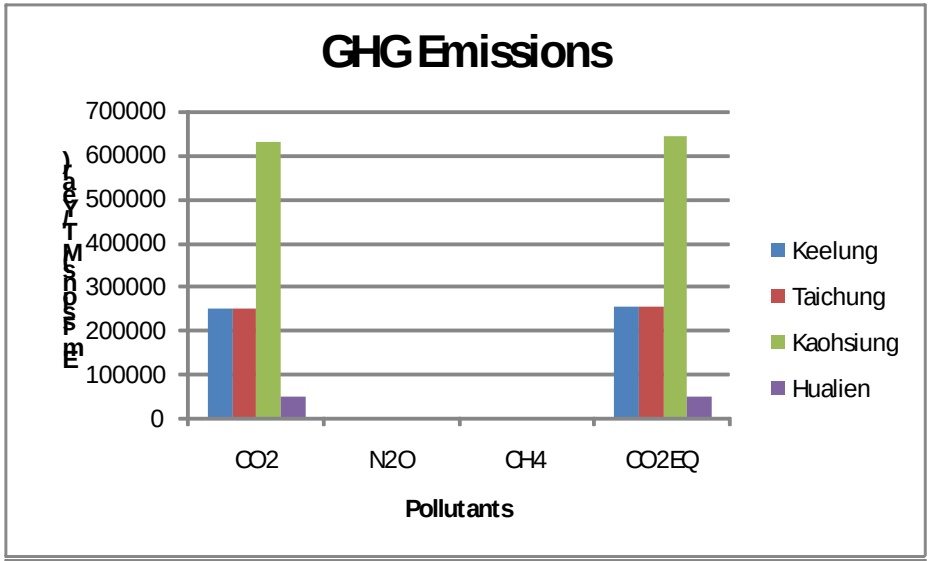
Unit: MT/Year

Port	Sources	NO_X	VOC	CO	SO_2	PM_{10}	$PM_{2.5}$	DPM	CO_{2EQ}
Kaohsiung Harbor	Ocean-going vessels	8499.9	343.7	756.6	8073.8	627.3	491.5	420.6	585367.2
	Harbor vessels	249.8	7	83.2	54.7	7.8	7.2	7.8	18190.3
	Cargo handling equipment	59.3	4.5	30.8	0.2	4.6	4.5	4.6	7879.2
	Rail	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Heavy-duty vehicles	482.5	72.9	329.3	0.8	28.8	25.5	28.8	32088.4
	Total	**9291.4**	**428.1**	**1200.0**	**8129.5**	**668.5**	**528.7**	**461.8**	**643525.1**
Hualien Harbor	Ocean-going vessels	679.2	24.4	57.4	511.6	42.7	33.7	32.9	41479.7
	Harbor vessels	38.9	0.9	7.9	6.1	1.0	0.9	1.0	2308.9
	Cargo Handling equipment	14.3	1.3	9.4	0.1	1.4	1.4	1.4	1967.4
	Rail	18.6	1.1	3.1	0.0	0.7	0.6	0.7	1218.9
	Heavy-duty vehicles	43.4	6.4	28.6	0.1	2.6	2.3	2.6	3016.9
	Total	**794.4**	**34.0**	**106.4**	**517.9**	**48.3**	**38.9**	**38.5**	**49991.9**

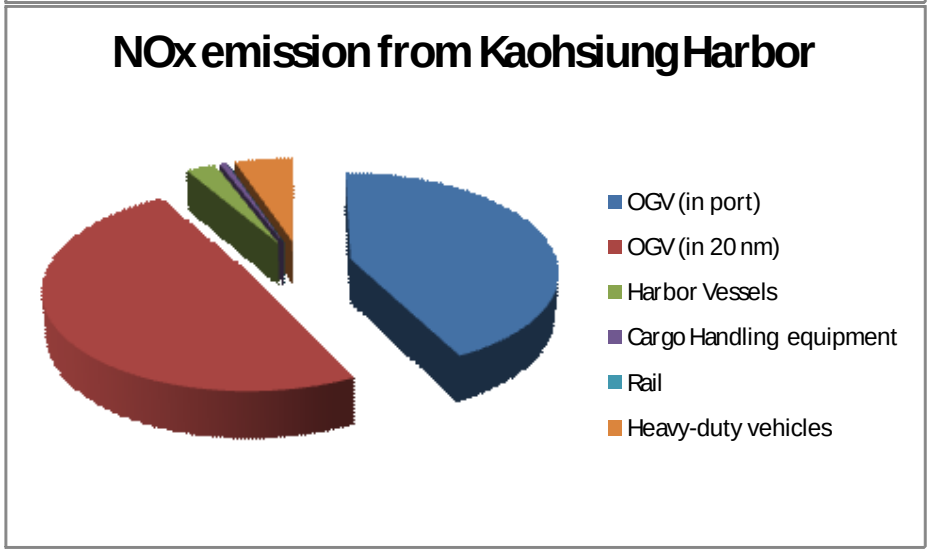
3. Current Results

Emission estimates results in the 4 harbors of Taiwan for year 2009





- NOx and SO_2 are the main pollutants. Emission amounts in Kaohsiung Harbor are the highest and are consistent with the volume of freight handled
- The main GHG is CO_2. The emissions of N_2O and CH_4 are rare. Kaohsiung Harbor has the highest level of GHG emissions.
- The main NOx emission from Kaohsiung Harbor is Ocean-Going-Vessels (OGV).



4. Future Plan

- This project will include Taipei harbor in the port air emissions inventory in the second year.
- Methodologies used in the first year will be discussed and modified to improve the emission estimates.

5. Conclusion

- This project estimates the emissions from Keelung, Taichung, Kaohsiung and Hualien Harbors and establishes detailed emission inventory data. The results would help to understand the composition of air pollutants from these port areas and help to construct the port control strategies.
- The results also showed that Kaohsiung harbor has the largest emissions, followed by Keelung and Taichung harbors, and Hualien harbor has the least emissions.
- Ocean going vessels are the major sources of all four ports. Transit within 20 nm from port emitted almost the same amount of pollutants as maneuvering and hotelling within port area. This Implies that control measures on OGVs within 20 nm from port are among important strategies.
- Harbor vessels and Heavy duty vehicles are the other two major sources except OGVs. Cargo handling equipment emitted only less emission since large cranes have been electrified. Locomotives has the least emission since only trivial lines are still working at two ports and none at the others.

Thank You!