IGES's Total Solution on Mitigation Actions in Developing Cities: A case in Semarang, Indonesia

The Institute for Global Environmental Strategies (IGES) and Semarang City Government concluded an agreement to collaborate and support the implementation of City Resilience Strategy (CRS) on 24 May, 2016. IGES provides a total solution on actionable plans by conducting the following activities (Figure 1):

1) Developing low-carbon society scenarios and multi sector action plans up to 2030
2) Conducting an in-depth study on one particular sector, i.e. transportation sector through co-benefit study
3) Translating policy recommendations into practical actions
4) Implementation of Project on Low Carbon Technologies.

These activities help cities to implement two out of six pillars of City Resilient Strategies, on Sustainable Water and Energy (Pillar No 1) and Integrated Mobility (Pillar no 4). This also helps cities to address the implementation of the Sustainable Development Goals (SDGs) goals 7 (Cities and Communities), 11 (Sustainable Cities), 13 (Climate Action) and 17 (Partnership for the Goals) at the city level.

To deliver the services in Semarang, in 2016 IGES began collaborating with several partners and worldwide organizations such as 100 Resilient Cities Program; Asian Institute of Technology, Institute for Transportation and Development Policy, and Save The Children. IGES also works closely with Japanese institutions such as Toyama City Government, National Institute on Environmental Studies, Mizuho Research Institute, E-Konzal, Pacific Consultant and Nippon Koei. IGES also established collaboration with local organisations including Diponegoro University and Initiative for Urban Climate Change and Environment. To provide those services, IGES received financial support mainly from the Ministry of the Environment, Japan (MOEJ).

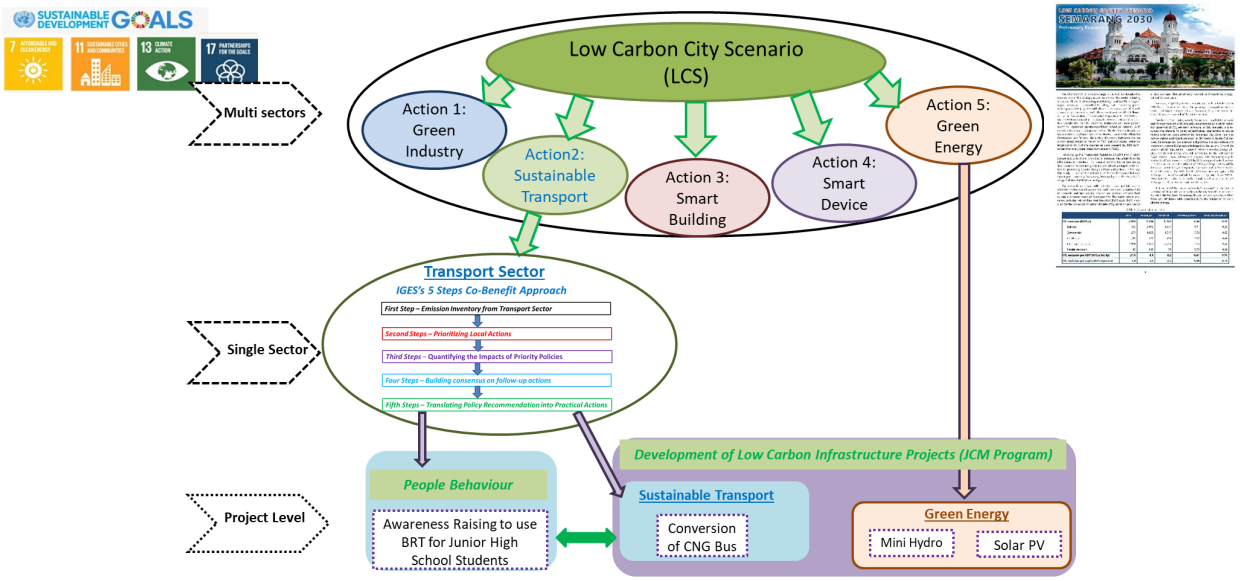

Figure 1.IGES's total solution for Semarang City

Developing Low Carbon Society (LCS) Scenario - Cross Sectoral Approach

IGES is collaborating with Diponegoro University and Asia-Pacific Integrated Model (AIM) team in Japan to develop a Low Carbon Society (LCS) Scenario for Semarang City. The research aims to contribute to promoting climate change actions and policies at the city level. The Low Carbon Society (LCS) Scenario is a guide to realising or achieving low or even zero emissions of greenhouse gases considering the future vision of society (Figure 2).

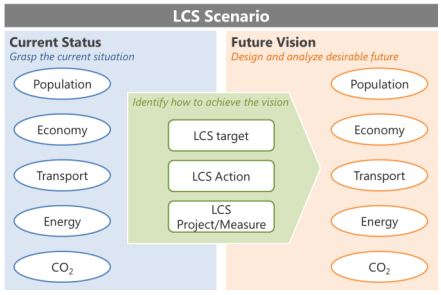

Figure 2. Brochure & Conceptual Framework of LCS Scenario

The Asia-Pacific Integrated Model (AIM) is a family of analytical models which are developed by research institutes in Japan. The model makes use of data and information based on existing plans at national and local levels. All the data are processed using a tool called the Asia-Pacific Integrated Model Extended Snapshot (ExSS) focusing on energy-related CO2 emissions. The total population of the city as of 2015 is 1,595,267 made up of 471,327 households, with a gross regional domestic product (GRDP) per capita of 6461.5 USD (1USD=13,000 IDR). The largest contributor to GRDP is the secondary sector such as manufacturing food, beverages and tobacco, chemical and pharmaceuticals, and other industries such as textiles and transport equipment. Semarang City's total CO_2 emissions were estimated to be 5,282 $ktCO_2e$ or 3.3tCO_2e/person in 2015. The industry sector is the sector emitting the largest amount of CO_2 in Semarang City.

Future Development and CO_2 Emissions

Total population will increase 1.29 times by 2030. At the same time, the number of households will increase 1.46 times. Simultaneously, macro economic indicators will increase around 6 times compared to the situation in 2015. The future GRDP will still be dominated by the secondary sector especially the construction industry, followed by the tertiary and primary sectors. Increasing population and income will also cause an increased consumption expenditure that will automatically increase final energy consumption (Table 1) and CO_2 emissions (Table 2).

Table 1. Final Energy Consumption by Sector (ktoe)

Sector	2015	2030BaU	2030CM	BaU/2015	CM/BaU
Industry	731,6	4.139,9	3.483,6	5,66	0,84
Commercial	71,7	507,6	442,5	7,08	0,87
Residential	392,2	615,8	605,1	1,57	0,98
Passenger transport	457,7	709,2	421,0	1,55	0,59
Freight transport	29,6	177,2	138,8	5,99	0,78
Total	**1.682,8**	**6.149,6**	**5.091,0**	**3,65**	**0,83**

Table 2.CO_2 emissions by sector and fuel ($ktCO_2e$)

	Sector	Coal	Oil	Gas	Electricity	**Total**
2015	Industry	497,0	492,5	586,8	948,2	**2.524,5**
	Commercial	0,0	45,3	5,7	520,0	**571,0**
	Residential	0,0	173,5	0,3	574,2	**748,0**
	Passenger transport	0,0	1.350,7	0,0	0,0	**1.350,7**
	Freight transport	0,0	87,3	0,0	0,0	**87,3**
	Total	**497,0**	**2.149,3**	**592,7**	**2.042,5**	**5.281,5**
2030 BaU	Industry	2.738,9	2.820,5	3.322,9	5.694,5	**14.576,9**
	Commercial	0,0	320,8	40,3	3.680,7	**4.041,7**
	Residential	0,0	272,4	0,4	901,5	**1.174,4**
	Passenger transport	0,0	2.093,0	0,0	0,0	**2.093,0**
	Freight transport	0,0	522,8	0,0	0,0	**522,8**
	Total	**2.738,9**	**6.029,5**	**3.363,7**	**10.276,8**	**22.408,9**
2030 CM	Industry	1.905,2	2.140,8	3.137,6	3.642,7	**10.826,3**
	Commercial	0,0	208,9	105,7	2.350,8	**2.665,3**
	Residential	0,0	272,4	0,4	588,8	**861,7**
	Passenger transport	0,0	1.182,6	40,6	23,2	**1.246,3**
	Freight transport	0,0	409,7	0,0	0,0	**409,7**
	Total	**1.905,2**	**4.214,5**	**3.284,3**	**6.605,5**	**16.009,4**

Low Carbon Society Scenario for Semarang City

Two scenarios, namely Business as Usual (BaU) scenario and Countermeasures (CM) scenario, are prepared to analyze the reduction potential of future CO_2 emissions. Under the BaU scenario, it is assumed that there is no policy or technology intervention to reduce carbon emissions, while an attempt to reduce carbon emissions is assumed in the CM scenario. The CO_2 emissions per capita are 3,3 tCO_2e/person in 2015 and will increase by more than 3 times from 2015 to 2030 under BaU scenario. Under the Countermeasures scenario, Semarang City Government will promote five LCS actions and implement various LCS projects related to the actions (Table3).

scenario will reduce emissions per capita of BaU by 2030 from 10.9 to 7.8 tCO_2e/person or around 28.44 %. One of the actions is named "Sustainable Transport", which promotes energy efficient vehicles and modal shift (Table 4). This will contribute to a reduction of 4.220 $ktCO_2e$. These actions and projects help the city to reduce CO_2 emissions by 29% compared to BaU scenario of CO_2 emissions per GDP in 2030 at around 26.9 tCO_2e/bil.

Semarang City has the potential to reduce CO2 emissions in line with the INDC of Indonesia. The city can be developed more effectively and efficiently by making contributions to climate change mitigation.

Table 3.The Five Low Carbon Society Scenario Projects in Semarang City

	Industry	Commercial	Residential	Passenger Transport	Freight Transport	**Total**
Action 1: Green Industry - Promotion of energy efficient equipment & fuel shift	2.552					**2.552**
Action 2: Smart Building - Diffusion of low-energy building (Materials, fuel shift)		215	33			**248**
Action 3: Smart Device - Promotion of energy efficient device/appliance		357	77			**434**
Action 4: Sustainable Transport - Energy efficient vehicle and modal shift				837	113	**950**
Action 5: Green Energy - deployment of renewable electricity		26	10			**36**
Total	**2.552**	**598**	**120**	**837**	**113**	**4.220**

Table 4.Low Carbon Society Actions on Sustainable Transport in Semarang City

No	Project	Emission reduction ($ktCO_2e$)
4-01	**Promotion of eco-driving with digital tachographs**	7.2
4-02	Wide-range traffic control	28.8
4-03	**Expansion of frequencies and routes of bus and BRT**	**96.2**
4-04	Development of public transportation like railway and MRT	98.6
4-05	**Shift to CNG bus**	6.1
4-06	Introduction of electric motorbikes	61.5
4-07	Promotion of energy-efficient vehicles (cars for passenger)	452.3
4-08	Promotion of energy-efficient vehicles (motorbikes)	86.7
4-09	Promotion of energy-efficient vehicles (trucks)	112.8
	Total	**950.1**

Co-benefit Study in Transport Sector at City Level—Sectoral Approach

The sectoral approach in Semarang City began with research on the possible benefits for climate change and air quality—also known as the co-benefits—of improving the public transport system since 2016. IGES has been collaborating with local governments, researchers and other partners on projects supported by the Ministry of the Environment, Japan (MOEJ). The research employed an evidence-based approach that consisted of five main steps: 1) developing an emissions inventory for air pollution and GHGs for the transport sector; 2) prioritising local policies and measures that could reduce air pollution and GHGs based on existing plans; 3) quantifying the impacts of priority policies and estimate reductions in air pollution and GHGs for selected policies; 4) building a consensus across relevant stakeholders on follow-up actions based on the quantitative analysis; and 5) translating policy recommendations into practical actions.

Based on the first and second steps of research, there were three top priority policies: 1) improving inter modality; 2) universal access to transport for all citizens; and 3) pedestrian access to the public transport system. Drawing upon the initial results, research team developed scenarios for a co-benefits study as follows: 1) modal shift increase riders on the BRT Trans Semarang; 2) Improve driving behaviour (eco-driving) along the BRT corridor; 3) introducing low-emission vehicles for new corridors and revitalisation of old fleets. The quantitative analysis shows first scenario brought about a 3-14% reduction in emissions relative to the current BRT bus; this was only <1% of the total 2015 emissions from the bus fleet in Semarang. However, scenario 1 offered considerably more emission reductions compared to other scenarios. Emission reductions from scenario 2 (eco-driving of BRT) were 16-20% of the total BRT emissions in 2015 but only 0.13-0.8% of the total bus fleet emissions. Emission reductions achieved under scenario 3 (low-emission bus for BRT fleet) were more significant, i.e. 50-99% of the current total emissions from the BRT bus fleet of corridor 1 which was 0.5-1% from the total bus fleet emissions in 2015.

The latter two scenarios contributed less significantly to the total emissions because the BRT buses contributed less than 4% to the total collective emissions from passenger fleets. Under scenario 3, significant emission reductions were also expected for some types pollutants while for a few others, such as for CO_2 and N_2O, an increase was shown which was due to the replacement of Euro2 BRT buses by the Euro4 buses .

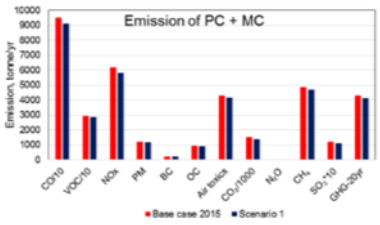

Figure 3. Emission Reduction due to Modal shift of BRT

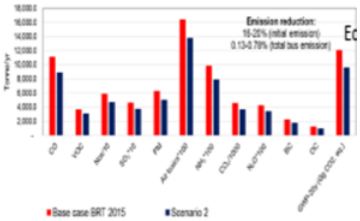

Figure 4. Emission Reduction of Eco Driving by Drivers of BRT

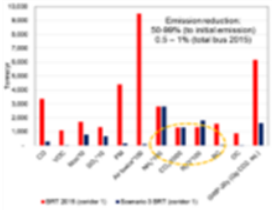

Figure 5. Emission Reduction of Low Carbon Technology of Bus

Following the analysis, a policy dialogue was convened to share the study's key results. The dialogue led those involved in Semarang to agree on the need to improve accessibility to the BRT, introduce low-carbon technology for bus fleets as well as pilots that focused to increase student ridership on the BRT (as students made up a large portion of the current ridership but often shifted to personal motorised transport as they grew older). The decisions coming out of this dialogue set the implementation of concrete plans based on the co-benefits analysis.

Translating Policy Research into Practical Actions and Project Development

Practical Actions

IGES is working together with Diponegoro University (UNDIP) and the Institute for Transportation Development Policy (ITDP) to develop policy guidelines to improve the BRT system in Semarang. The guidelines focus on hard infrastructure and are being developed through a "place making" approach. This approach could be one solution to create quality of space for residents. It relies on examining several key elements related to urban planning such as: 1) mixed-uses; 2) multiple transport options; 3) public space; 4) preservation of historic structures; 5) community engagement; 6) arts, culture and creativity; and 7) recreation.

Source: ITDP-IGES

Figure 6. Guidelines to Improve BRT Services

IGES also sought changes to behaviours and attitudes involving the BRT. Working with the Initiative for Urban Climate Change and Environment (IUCCE) and Save The Children (STC), a pilot activity was introduced to help test and validate some of the recommendations on changing behaviour from the research. In particular, these activities focused on how to make public transport safer and encourage the switch from private vehicles to the BRT. Rather than moving to motorcycles, the hope was that students would be motivated to continue using public transport. Further, to promote the participation of the young generation in the design of a future public transport system, junior high school students were asked to develop a brief essay or illustration of what a sustainable transport system looked like for them. The students with the best essay or illustration were given a bicycle as a reward.

Figure 7. Awareness Raising Activities

Development of JCM Model Project

In parallel, in 2017 IGES also worked with other organisations to conduct feasibility of introducing low-carbon technology for the bus fleets. This feasibility study was conducted under the joint crediting mechanism (JCM) program of city-to-city cooperation between Toyama – Japan and Semarang City funded by Ministry of the Environment, Japan (MOEJ). The feasibility study focuses on renewable energy (mini-hydro and solar PV) and green transportation. The study recommend a bus retrofit program of the engine with hybrid Diesel-Compressed Natural Gas (CNG) system. The project aims to improve operational cost (fuel saving) and reduce CO_2 emissions simultaneously. Through the modification of the engine from diesel to a hybrid of diesel and compressed natural gas (CNG), the consumption of fuel will fall, leading to cost savings, a reduction in GHG emissions of about 819 ton CO_2/year and a reduction in air pollutants. Having understood the merits of the retrofit program, Trans Semarang, the operator of BRT, and the other collaborating entity from Toyama City, Hokusan Co, Ltd, agreed to submit a joint proposal to the JCM to subsidise the costs of the new engines. The proposal was approved and selected as a model project for fiscal year 2018 by MOEJ. About 72 of the Trans Semarang buses became fully hybrid Diesel-CNG Buses by the end of 2018. The launch ceremony for the JCM model project was held on 9 January, 2019 in Semarang City.

Figure 8. Launch Ceremony for JCM Project on 9 January, 2019

Way Forward

Transformative process from policy oriented research activities to practical actions and project developments on transport sector in Semarang City brought multiple benefit to the city. The case on transport sector could be expanded to other sectors to achieve the Sustainable Development Goals (SDGs) target in Semarang City. Semarang's case could offer other cities in Indonesia and Asia useful insight on the path to a more sustainable future.

For further information, please contact us:
Sudarmanto Budi Nugroho: nugroho@iges.or.jp