Session II:
Singapore's Transition to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories

13th July 2021

Presented at: The 18th Workshop on GHG Inventories in Asia (WGIA18)

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1 Background

Background

1. Under current UNFCCC reporting guidelines, non-Annex I Parties (NAIP) are required to use the Revised 1996 Intergovernmental Panel on Climate Change (IPCC) Guidelines for estimation and reporting of National Greenhouse Gas Inventories.

2. In preparation for possible transition to 2006 IPCC Guidelines, Singapore carried out the preparatory work by building capacity.

3. Emissions were estimated using 2006 IPCC Guidelines in the 4th Biennial Update Report (published in 2020) – earlier BURs using a mix of Rev 1996 & 2006 IPCC Guidelines

Background

2015

Built technical knowledge of GHG inventory compilers through technical workshops related to 2006 IPCC-GLs

2016

Carried out an staff-level assessment on the switch to 2006 IPCC-GLs for 2014 data

2018

initiated work to transit to 2006 IPCC Guidelines for other years

2020

Completed the transition fully to 2006 IPCC Guidelines, Fifth Assessment Report (AR5) GWP

2 Transition from Revised 1996 IPCC Guidelines to 2006 IPCC Guidelines

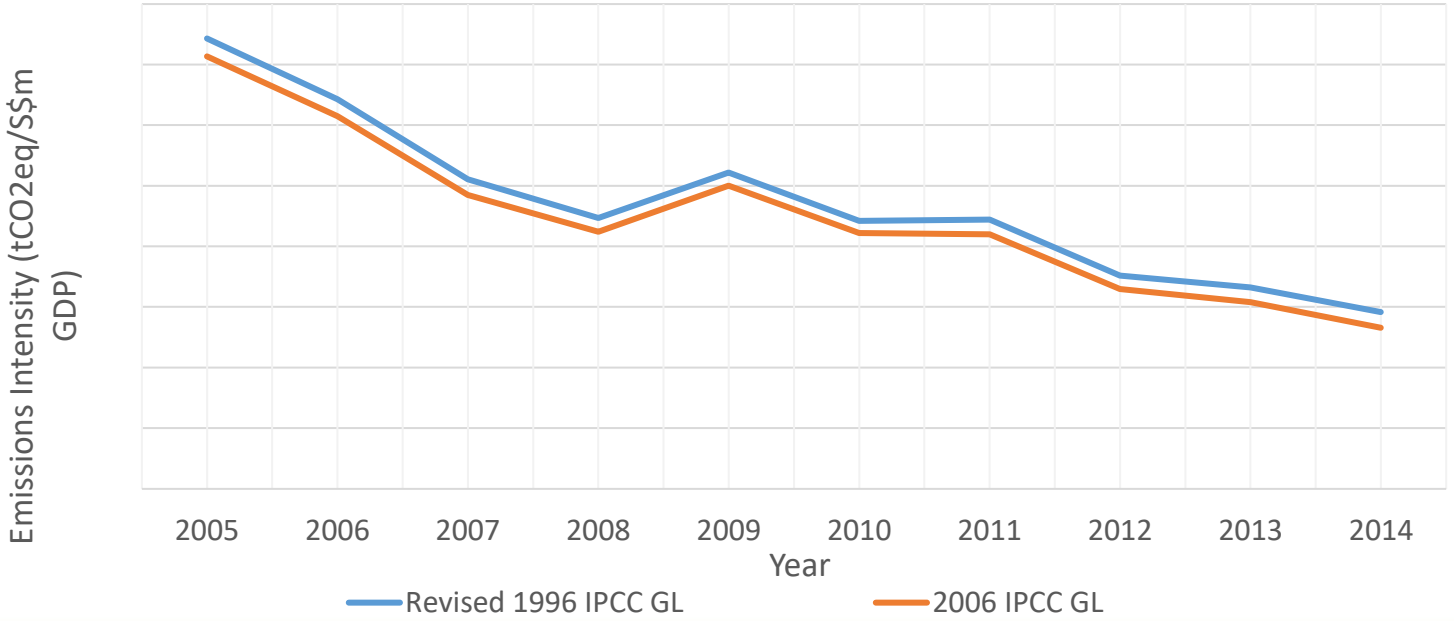
Transition from Revised 1996 IPCC Guidelines to 2006 IPCC Guidelines

1. Effect on national greenhouse (GHG) inventory
   - With the transition from

     (i) Revised 1996 IPCC Guidelines to 2006 IPCC Guidelines,

     (ii) IPCC second assessment report (SAR) to IPCC fifth assessment report (AR5) global warming potential (GWP) values

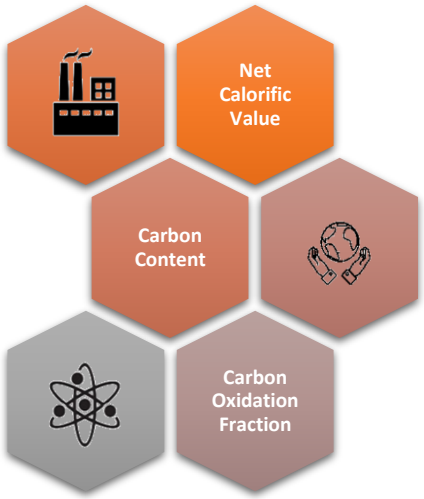
     (iii) inclusion of NF3
   - The total annual national GHG emissions had decreased by 1-2%, the emission intensity had also decreased



Transition from Revised 1996 IPCC Guidelines to 2006 IPCC Guidelines

2. Updated calculation factors: Net Calorific Value (NCV), Carbon Content (CC) and Carbon Oxidation Fraction (COF)

- GHG emissions = Fuel consumption x **Emission Factor**
- Emission Factor = **NCV** x **CC** x **COF**



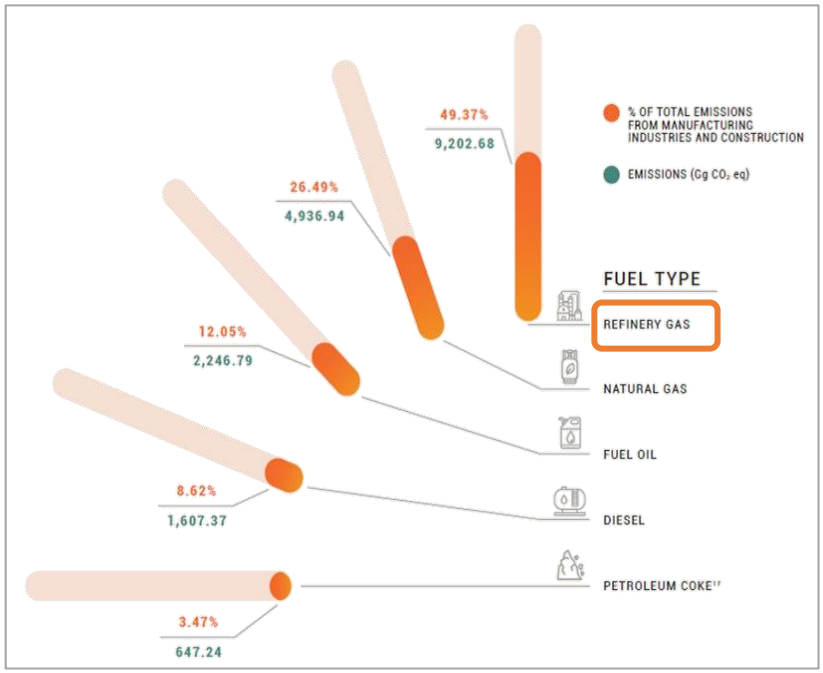
Fuel type	Net Calorific Value		Carbon Content		Fraction of Carbon Oxidised		CH4 Emission Factor		N2O Emission Factor	
	(TJ/Unit)		(tC/TJ)				(kg/TJ)		(kg/TJ)	
	1996	2006	1996	2006	1996	2006	1996	2006	1996	2006
Residual Fuel Oil	40.19	40.4	21.1	21.1	0.99	1	3	3	0.6	0.6
Gas/Diesel Oil	43.33	43	20.2	20.2	0.99	1	3	3	0.6	0.6
Natural Gas	41.868	41.868	15.3	15.3	0.995	1	1	1	0.1	0.1
Orimulsion	27.5	27.5	22	21	0.99	1		3		0.6
Coal	28	25.8	25.8	25.8	0.98	1	1	1	1.4	1.5
Refinery Gas	48.15	49.5	18.2	15.7	0.99	1		1		0.1
Other Kerosene	44.75	43.8	19.6	19.6	0.99	1		3		0.6
Liquefied Petroleum Gases	47.31	47.3	17.2	17.2	0.99	1		1		0.1
Petroleum Coke	31	32.5	27.5	26.6	0.99	1	2	3	0.6	0.6
Petrol (Motor Gasoline)	44.8	44.3	18.9	18.9	0.99	1	25	25	3.9	3.9
Diesel	43.33	43	20.2	20.2	0.99	1	8	8	3.9	3.9
CNG	41.868	41.868	15.3	15.3	0.995	1	50	92	0.1	3

Factors in blue indicate changes in 2006 IPCC Guidelines.
Grey out cells indicate no stated emission factor by 1996 IPCC Guidelines.

Transition from Revised 1996 IPCC Guidelines to 2006 IPCC Guidelines

3. Mainly affects emissions from refinery gas due to significant change in carbon content for refinery gas, making up about 50% of industry sector emissions and about 20% of total national emissions.

IPCC Category Code	IPCC Category	Fuel Type	Greenhouse Gas	Emissions (Gg CO_2 eq)	Percentage Contribution	Cumulative Total of Column E
1A1	Fuel Combustion Activities - Energy Industries	Natural Gas	CO_2	17,330.58	34.2%	34.2%
1A2	Fuel Combustion Activities - Manufacturing Industries and Construction	Refinery Gas	CO_2	9,193.98	18.1%	52.3%
1A2	Fuel Combustion Activities - Manufacturing Industries and Construction	Natural Gas	CO_2	4,932.17	9.7%	62.0%
1A3b	Fuel Combustion Activities - Transport - Road Transportation	Diesel	CO_2	4,631.09	9.1%	71.2%
1A3b	Fuel Combustion Activities - Transport - Road Transportation	Motor Gasoline	CO_2	2,419.49	4.8%	75.9%
1A2	Fuel Combustion Activities - Manufacturing Industries and Construction	Fuel Oil	CO_2	2,239.75	4.4%	80.4%
1A2	Fuel Combustion Activities - Manufacturing Industries and Construction	Diesel	CO_2	1,602.12	3.2%	83.5%
1A1	Fuel Combustion Activities - Energy Industries	Solid Waste[29]	CO_2	1,542.32	3.0%	86.6%
2E	Industrial Processes and Product Use - Electronics Industry	–	PFCs	1,235.41	2.4%	89.0%
1B2	Fugitive Emissions from Fuels	Oil and Natural Gas	CO_2	1,085.75	2.1%	91.1%
1A1	Fuel Combustion Activities - Energy Industries	Coal	CO_2	1,026.71	2.0%	93.2%
1A2	Fuel Combustion Activities - Manufacturing Industries and Construction	Petroleum Coke[30]	CO_2	645.54	1.3%	94.4%
2F	Industrial Processes and Product Use - Product Uses as Substitutes for Ozone Depleting Substances	–	HFCs	396.97	0.8%	95.2%



Newly transited to 2006 IPCC Guidelines

Already using 2006 IPCC Guidelines

3 Challenges and limitations

Challenges and limitations

1. Transport sector
   - Before transiting to 2006 IPCC Guidelines, Tier 2 was used to compute CH4 and N2O emissions based on 1996 IPCC Guidelines
   - However, to transit to 2006 IPCC Guidelines at the same tier, new data is required. That is, fuel consumed by emission control technology
   - Due to the unavailable data, a shift to lower tier (Tier 1) in 2006 IPCC Guidelines was inevitable

The emission equation for Tier 2 is:

EQUATION 3.2.4
TIER 2 EMISSIONS OF CH_4 AND N_2O

$$Emission = \sum_{a,b,c} [Fuel_{a,b,c} \bullet EF_{a,b,c}]$$

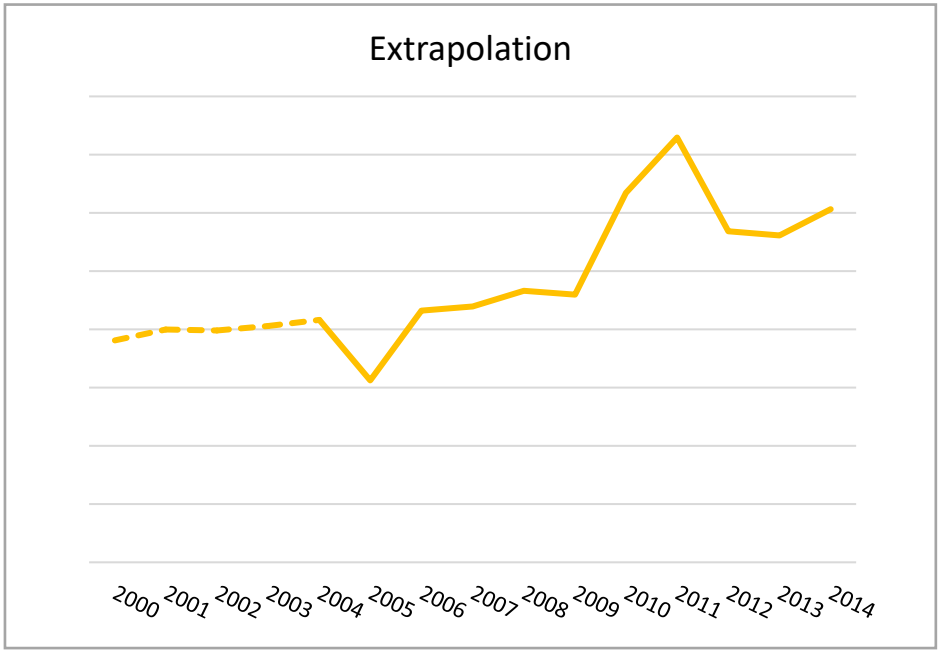
Where:

Emission	= emission in kg.
$EF_{a,b,c}$	= emission factor (kg/TJ)
$Fuel_{a,b,c}$	= fuel consumed (TJ) (as represented by fuel sold) for a given mobile source activity
a	= fuel type (e.g., diesel, gasoline, natural gas, LPG)
b	= vehicle type
c	= emission control technology (such as uncontrolled, catalytic converter, etc)

An extract from 2006 IPCC Guideline

Challenges and limitations

2. Recalculations
   - Where historical activity data are not available for certain years
     - Surrogate method was used e.g. for certain fuel type such as LPG and IPPU streams
     - Extrapolation method was used e.g. waste stream, domestic bunker



Challenges and limitations

2. Recalculations (cont'd)

- increase in GHG emissions in the years 1994 and 2000 was largely due to revision in data or unavailability of data in the earlier years which has now been included through splicing techniques.

Before splicing technique were applied

S/N	Net National Emissions	Guidelines Used / Reference for GWPs / Inclusion of NF_3	1994	2000	2010	2012	2014
			($Gg\ CO_2$ eq)				
1	Net National Emissions reported in 4th NC / 3rd BUR	Revised 1996 IPCC Guidelines / SAR	26,800.37	38,329.57	47,062.48	48,567.65	50,908.13
2	Net National Emissions *(before splicing techniques were applied)*	2006 IPCC Guidelines / AR5 / NF_3 included	27,482.27	38,338.65	46,065.96	47,801.44	49,943.35
% DIFFERENCE BETWEEN ROWS 1 AND 2:			2.5%	0.0%	-2.1%	-1.6%	-1.9%

After splicing technique were applied

S/N	Net National Emissions	Guidelines Used / Reference for GWPs / Inclusion of NF_3	1994	2000	2010	2012	2014
			($Gg\ CO_2$ eq)				
1	Net National Emissions reported in 4th NC / 3rd BUR	Revised 1996 IPCC Guidelines / SAR	26,800.37	38,329.57	47,062.48	48,567.65	50,908.13
3	Net National Emissions reported in 4th BUR *(with splicing techniques applied)*	2006 IPCC Guidelines / AR5 / NF_3 included	28,115.53	38,952.34	46,142.83	47,909.83	49,943.35
% DIFFERENCE BETWEEN ROWS 1 AND 3:			4.9%	1.6%	-2.0%	-1.4%	-1.9%

Learning Points

a) Extensive effort to re-trace, check and update past years' GHG data

b) Need to disaggregate data according to fuel so as to apply 2006 IPCC G/Ls factors

c) Document all the methodologies and computations required for the compilation of GHG inventory in line with Quality Assurance/ Quality Control (QA/ QC) process.

d) Continual learning process to improve the inventory

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