Method of Stating Energy Consumption

2016

Part 1: Literature review

- **Four observations:**
  - Many papers are related to the assessment of energy saving and GHG emission reductions of EV in different countries or districts.
  - Upstream stage of power supply should be covered for EV assessment.
  - The data of electricity mix and upstream emissions factor of different power supplying can be collected in most of countries.
  - A standardized method for calculating and stating energy consumption and the associated GHG emissions for electrified vehicles is therefore recommended for consideration.

Part 2: Calculation methods suggested

■ Methods overview

- The methods are suggested to use EXCEL tools to get Life cycle analysis results.
- Electricity chains and vehicle running are considered in the calculation, that is, upstream and operation stages are both covered in life cycle consumption and emissions.
- Data for fossil fuel and non-fossil fuel to power.
  - ✓ Three kinds of fossil fuels including Coal, Oil and Natural gas are used as feedstock in power generation. Energy consumption and emissions include the upstream stages, such as feedstock exploration, transportation, fuel production, and transportation, in addition to the energy consumption emissions occurring in the fuel utilization; but the facility construction and vehicle manufacturing stages are excluded for their little effect on the life cycle energy consumption and emission
  - ✓ Non-fossil fuels includes Hydro, Nuclear, Solar, Wind and other types. The energy consumption and emission during facility manufacturing and factory construction stages are allocated to the total power supplying during the whole life time of those power stations for they account for a very large proportion.

Part 2: Calculation methods suggested

- Life cycle **energy consumption and GHG emission** per unit distance driven by EV and PHEV can be calculated based on some data collected for the specific region

1. Calculation formula of energy consumption

$$EN_{EV} = \left[\frac{E_{LC,Coal}}{\eta_{Coal-to-ele}} * SH_{Coal} + \frac{E_{LC,NG}}{\eta_{NG-to-ele}} * SH_{NG} + \frac{E_{LC,Oil}}{\eta_{Oil-to-ele}} * SH_{Oil} + \sum_{k=1}^{i} E_{LC,k} * SH_k \right] * \frac{1}{1-\eta_{Loss}} * \frac{E_{Ele,EV}}{\eta_{Charge}} * \frac{3.6}{100}$$

$$EN_{PHEV} = \left[\frac{E_{LC,Coal}}{\eta_{Coal-to-ele}} * SH_{Coal} + \frac{E_{LC,NG}}{\eta_{NG-to-ele}} * SH_{NG} + \frac{E_{LC,Oil}}{\eta_{Oil-to-ele}} * SH_{Oil} + \sum_{k=1}^{i} E_{LC,k} * SH_k \right] * \frac{1}{1-\eta_{Loss}} * \frac{E_{Ele,PHEV}}{\eta_{Charge}} * \frac{3.6}{100} * SH_{Ele}$$

$$+(1-SH_{Ele}) * E_{LC,Gasoline} * V_{Gasoline} * Q_{Gasoline} * \frac{1}{100}$$

- $E_{LC,Coal}$: Life cycle energy consumption for coal production and distribution (MJ/MJ fuel obtained)
- $\eta_{Coal-to-ele}$: Coal power electricity generation efficiency(%)
- SH_{Coal}: The share of coal power in the total electricity supplying of regional electrical grids(%)
- k: The type of non-fossil fuel power from 1 to j mean: Hydro, Nuclear, …
- $E_{LC,K}$: Life cycle energy consumption for electricity generation and supply of type k (MJ/MJ power supplying)
- SH_k: The share of non-fossil fuel type k in the total electricity supplying(%)
- η_{Loss}: Electricity transmission loss rate (%)
- $E_{Ele,EV}$: Direct energy consumption of EV (kWh/100km)
- SH_{Ele}: The range share by electricity(%)
- η_{Charge}: Charging Efficiency (%)
- $E_{Ele,PHEV}$: Direct energy consumption of PHEV (kWh/100km)
- Q_{Gasoline}: Calorific value of gasoline (32 MJ/L)
- $E_{LC,\mathrm{Gasoline}}$: Life cycle energy consumption for gasoline production and utilization(MJ/MJ)
- V_{Gasoline}: Energy consumption of PHEV driven by gasoline in running stage(Liter/100km)

Part 2: Calculation methods suggested

2. Calculation formula of Life cycle GHG emission

$$EM_{EV} = \left[\frac{EM_{LC,Coal}}{\eta_{Coal-to-ele}} * SH_{Coal} + \frac{EM_{LC,NG}}{\eta_{NG-to-ele}} * SH_{NG} + \frac{EM_{LC,Oil}}{\eta_{Oil-to-ele}} * SH_{Oil} + \sum_{k=1}^{i} EM_{LC,k} * SH_k \right] * \frac{1}{1-\eta_{Loss}} * \frac{E_{Ele,EV}}{\eta_{Charge}} * \frac{3.6}{100}$$

$$EM_{PHEV} = \left[\frac{EM_{LC,Coal}}{\eta_{Coal-to-ele}} * SH_{Coal} + \frac{EM_{LC,NG}}{\eta_{NG-to-ele}} * SH_{NG} + \frac{EM_{LC,Oil}}{\eta_{Oil-to-ele}} * SH_{Oil} + \sum_{k=1}^{i} EM_{LC,k} * SH_k \right] * \frac{1}{1-\eta_{Loss}} * \frac{E_{Ele,PHEV}}{\eta_{Charge}} * \frac{3.6}{100} * SH_{Ele}$$

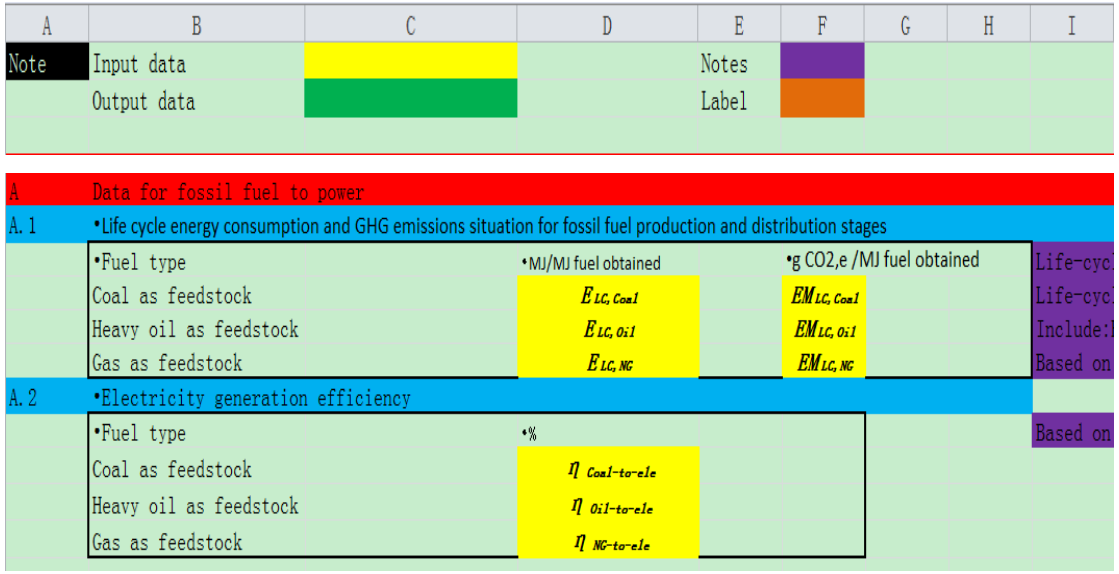
$$+(1-SH_{Ele}) * EM_{LC,Gasoline} * V_{Gasoline} * Q_{Gasoline} * \frac{1}{100}$$

- $EM_{LC,Coal}$: Life cycle GHG emission for coal production and distribution (g CO2, e/MJ)
- $\eta_{Coal-to-ele}$: Coal power electricity generation efficiency(%)
- SH_{Coal}: The share of coal power in the total electricity supplying of regional electrical grids(%)
- k: The type of non-fossil fuel power from 1 to j mean: Hydro, Nuclear, …
- $EM_{LC,K}$: Life cycle GHG emission for electricity generation and supply of type k (g CO2, e/MJ power supplying)
- SH_k: The share of non-fossil fuel type k in the total electricity supplying(%)
- η_{Loss}: Electricity transmission loss rate (%)
- $E_{Ele,EV}$: Direct energy consumption of EV (kWh/100km)
- SH_{Ele}: The range share by electricity(%)
- η_{Charge}: Charging Efficiency (%)
- $E_{Ele,PHEV}$: Direct energy consumption of PHEV (kWh/100km)
- Q_{Gasoline}: Calorific value of gasoline (32 MJ/L)
- $EM_{LC,\mathrm{Gasoline}}$: Life cycle GHG emission for gasoline production and utilization(67.91 g CO2, e/MJ)
- V_{Gasoline}: Energy consumption of PHEV driven by gasoline in running stage(Liter/100km)

Part 3: Operating manual

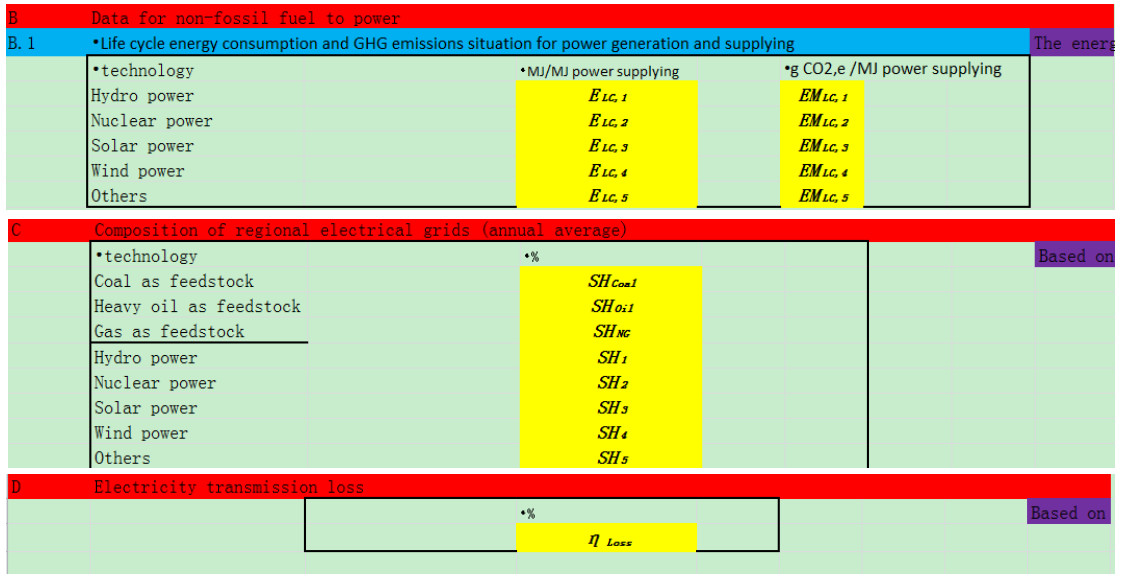
- The methods are based on EXCEL tools to get life cycle analysis results. Based on the data of different regions and countries input in the Yellow Cell, the results will be showed in the output cell (the Green Cell) and the labelling is presented in the Orange Cell. The data is explained in the Purple Cell.

1. Upstream stage



A	B	C	D	E	F	G	H	I
Note	Input data			Notes				
	Output data			Label				

A	Data for fossil fuel to power			
A. 1	•Life cycle energy consumption and GHG emissions situation for fossil fuel production and distribution stages			
	•Fuel type	•MJ/MJ fuel obtained	•g CO2,e /MJ fuel obtained	Life-cyc
	Coal as feedstock	$E_{LC,Coal}$	$EM_{LC,Coal}$	Life-cyc
	Heavy oil as feedstock	$E_{LC,Oil}$	$EM_{LC,Oil}$	Include:
	Gas as feedstock	$E_{LC,NG}$	$EM_{LC,NG}$	Based on
A. 2	•Electricity generation efficiency			
	•Fuel type	•%		Based on
	Coal as feedstock	$\eta_{Coal-to-ele}$		
	Heavy oil as feedstock	$\eta_{Oil-to-ele}$		
	Gas as feedstock	$\eta_{NG-to-ele}$		



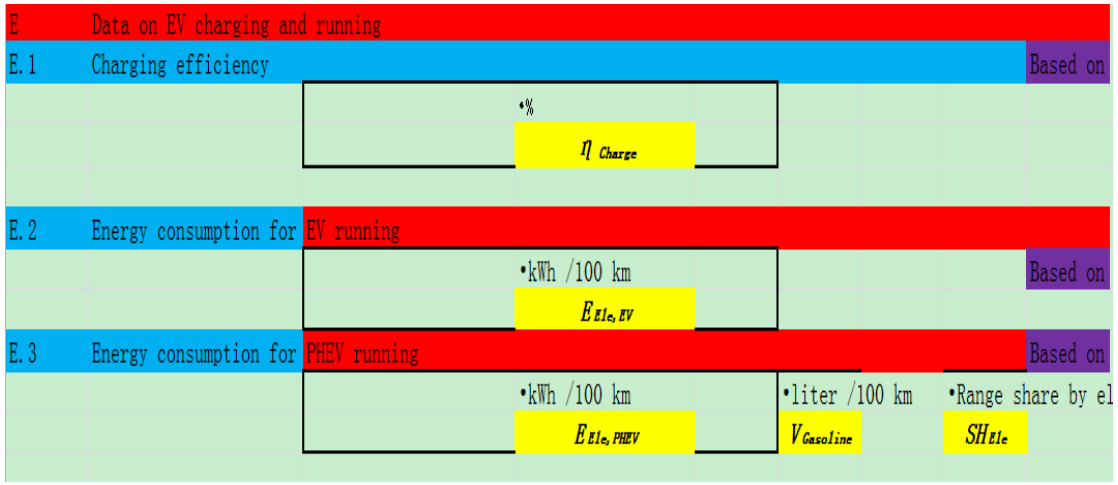
B	Data for non-fossil fuel to power		
B. 1	•Life cycle energy consumption and GHG emissions situation for power generation and supplying		The energ
	•technology	•MJ/MJ power supplying	•g CO2,e /MJ power supplying
	Hydro power	$E_{LC,1}$	$EM_{LC,1}$
	Nuclear power	$E_{LC,2}$	$EM_{LC,2}$
	Solar power	$E_{LC,3}$	$EM_{LC,3}$
	Wind power	$E_{LC,4}$	$EM_{LC,4}$
	Others	$E_{LC,5}$	$EM_{LC,5}$

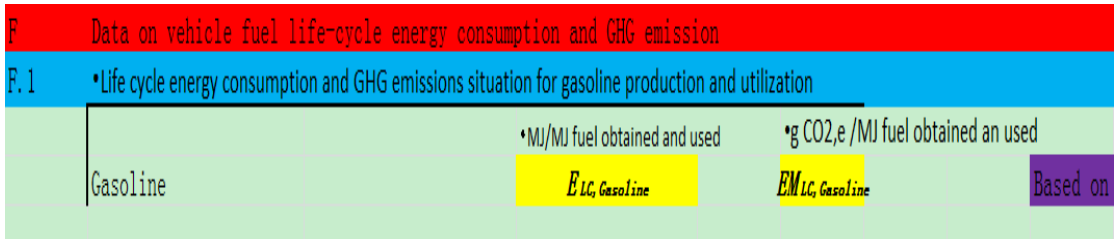
C	Composition of regional electrical grids (annual average)		
	•technology	•%	Based on
	Coal as feedstock	SH_{Coal}	
	Heavy oil as feedstock	SH_{Oil}	
	Gas as feedstock	SH_{NG}	
	Hydro power	SH_1	
	Nuclear power	SH_2	
	Solar power	SH_3	
	Wind power	SH_4	
	Others	SH_5	

D	Electricity transmission loss		
		•%	Based on
		η_{Loss}	

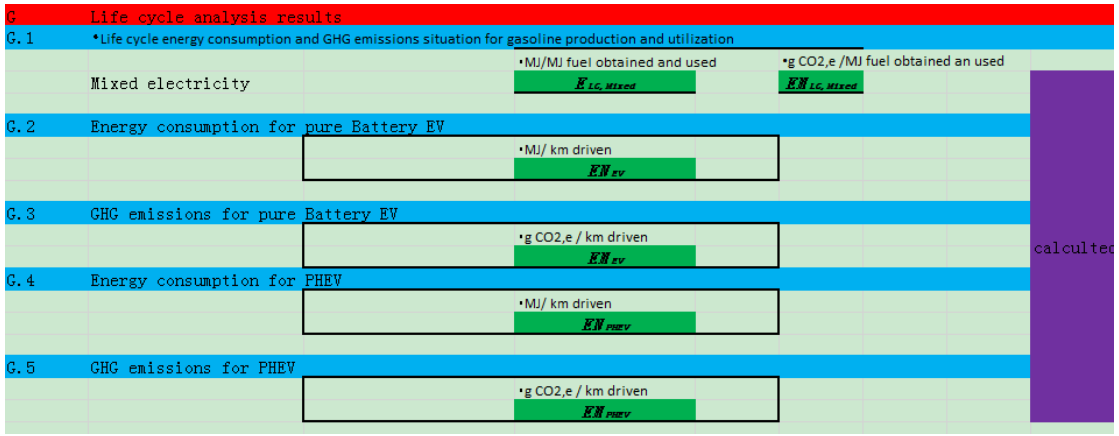
Part 3: Operating manual

2. Running stage





3. Calculation result



Part 4: DATA to collect

- The data should be collected with clear sources such as statistical book or formal report.

Fuel Type	Life cycle energy consumption and GHG emissions situation for fossil fuel production and distribution stages		Electricity generation efficiency (%)
	Energy Consumption (MJ/MJ fuel obtained)	GHG Emissions (g CO2,e /MJ fuel obtained)	
Coal as feedback			
Heavy oil as feedback			
Gas as feedback			
Others(please add)			

Technology	Life cycle energy consumption and GHG emissions situation for power generation and supplying	
	Energy Consumption (MJ/MJ power supplying)	GHG Emissions (g CO2,e /MJ power supplying)
Hydro Power		
Nuclear Power		
Solar Power		
Wind Power		
Others(please add)		

Part 4: DATA to collect

Fuel Type / Technology	Composition of regional electrical grids (annual average) / Percentage (%)
Coal as feedback	
Heavy oil as feedback	
Gas as feedback	
Wind Power	
Hydro Power	
Nuclear Power	
Solar Power	
Wind Power	
Others(please add)	

Electricity transmission loss (%)	

	Life cycle energy consumption and GHG emissions situation for gasoline production and utilization	
	Energy Consumption (MJ/MJ fuel obtained and used)	GHG Emission (g CO2,e /MJ fuel obtained an used)
Gasoline		

Part 4: DATA to collect

Charging efficiency (%)	

	Energy consumption for EV /PHEV running by electricity	
	BEV	PHEV
Energy consumption(kWh /100 km)		

	Energy consumption for PHEV running by gasoline
Energy consumption (liter /100 km)	

Range share by electricity for PHEV (%)	

Part 4: DATA to collect

The data mentioned above are as follows:

1. Data on electricity chains

- Life cycle energy consumption and GHG emissions situation for fossil fuel production and distribution stages of power generation(Coal, Oil, Gas)
  - MJ/MJ fuel obtained
  - g CO2,e /MJ fuel obtained
- Electricity generation efficiency (%, by type)
- Life cycle energy consumption and GHG emissions situation for non fossil fuel power generation and supplying(Hydro, Nuclear, Solar, Wind and others)
  - MJ/MJ power supplying
  - g CO2,e /MJ power supplying
- Composition of regional electrical grids (%)(Coal, Oil, Gas, Hydro, Nuclear, PV, Wind and others)
- Electricity transmission loss (%)

2. Data on EV/PHEV charging and running

- Charging efficiency (%)
- Energy consumption for BEV running (kWh /100 km)
- Energy consumption for PHEV running driven by electricity(kWh /100 km)
- Energy consumption for PHEV running driven by gasoline(liter /100 km)
- The range share by electricity for PHEV (%)

Part 5: Stating Methods Suggested

About the stating methods, some rules are suggested.

1. Labelling together
   - kWh /100 km
   - Liter (gasoline equivalent)/ 100 km
2. Considering energy consumption by upstream and operation stages
   - Upstream (percentile)
   - Operation (percentile)
3. Comparing GHG emissions to conventional gasoline vehicle
   - Total
   - By stages

Part 6: Supports are welcomed from contracting parties

- The data listed in Part 4 should be collected with clear sources such as statistical book or formal report.
- Modifications suggestion for our suggested methods, with the presentation about the experiences of current calculation and labelling methods in specific regions.

Appendix : Demonstration of situation in China

- Input data : be collected from statistical book and formal report.

Fuel Type	Life cycle energy consumption and GHG emissions situation for fossil fuel production and distribution stages		Electricity generation efficiency (%)
	Energy Consumption (MJ/MJ fuel obtained)	GHG Emissions (g CO2,e /MJ fuel obtained)	
Coal as feedback	1.039	93.56	36.5
Heavy oil as feedback*	1.205	92.73	36.5
Gas as feedback	1.107	66.06	45
Others(please add)			

Technology	Life cycle energy consumption and GHG emissions situation for power generation and supplying*	
	Energy Consumption (MJ/MJ power supplying)	GHG Emissions (g CO2,e /MJ power supplying)
Hydro Power	0	2.81
Nuclear Power	0	3.31
Solar Power	0	15.69
Wind Power	0	5
Others(please add)	0	5.9

Appendix : Demonstration of situation in China

Fuel Type / Technology	Composition of regional electrical grids (annual average) / Percentage (%)
Coal as feedback	77
Heavy oil as feedback	1
Gas as feedback	1
Hydro Power	16
Nuclear Power	2
Solar Power	1
Wind Power	1
Others(please add)	1

Electricity transmission loss (%)	6

	Life cycle energy consumption and GHG emissions situation for gasoline production and utilization	
	Energy Consumption (MJ/MJ fuel obtained and used)	GHG Emission (g CO2,e /MJ fuel obtained an used)
Gasoline	1.282	92.7

Appendix : Demonstration of situation in China

Charging efficiency (%)	**90**

	Energy consumption for EV /PHEV running by electricity	
	BEV	PHEV
Energy consumption(kWh /100 km)	16	16

	Energy consumption for PHEV running by gasoline
Energy consumption (liter /100 km)	7

Range share by electricity for PHEV (%)	50

Notes: Data related to vehicles are for demonstration

Appendix : Demonstration of situation in China

- Output data : Calculation result

G	Life cycle analysis results							
G. 1	•Life cycle energy consumption and GHG emissions situation for mixed electricity generation and supplying							
			•MJ/MJ fuel obtained and used		•g CO2,e /MJ fuel obtained an use			
	Mixed electricity		2. 39		214. 95			
G. 2	Energy consumption for pure Battery EV							
			•MJ/ km driven					
			1. 53					
G. 3	GHG emissions for pure Battery EV							
			•g CO2,e / km driven					
			137. 6					
G. 4	Energy consumption for PHEV							
			•MJ/ km driven					
			2. 20					
G. 5	GHG emissions for PHEV							
			•g CO2,e / km driven					
			172. 6					
H	Labelling							
H. 1	•for BEV							
	Direct energy consumpti	16	kWh /100 km		or	1. 8	Liter (gasoline equivalent)/ 100 km	
			energy comsumption		percentile		GHG emissions	percentile
	Vehicle running stage		0. 58	MJ/km	38%		0. 0	g CO2, e / 0%
	Upstream stage		0. 96	MJ/km	62%		137. 6	g CO2, e / 100%
H. 2	•for PHEV							
	Direct energy consumpti	39	kWh /100 km		or	4. 4	Liter (gasoline equivalent)/ 100 km	
			energy comsumption		percentile		GHG emissions	
	Vehicle running stage		1. 41	MJ/km	64%		76. 1	g CO2, e / 44%
	Upstream stage		0. 79	MJ/km	36%		96. 6	g CO2, e / 56%

Thanks