Method of Stating Energy Consumption

2016.4

Part 1: Literature review

- Based on the literature review, there are four observations:

- Many papers are related to the assessment of energy saving and GHG emission reductions of EV in different countries or districts.(And the reference papers are list in the report)
- 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 and regions.
- 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

1. Methods and boundary

- The life-cycle analysis was conducted with the functional unit of 1 kilometer driven by an EV under real-world driving conditions .A model based on Excel was applied to perform the life-cycle analysis.
- Electricity chains and vehicle running were considered in the calculation, that is, upstream and operation stages are both covered in life cycle consumption and emissions. Vehicle manufacturing stage is excluded.
- **Fossil fuel(Coal, Oil, NG) to power:** energy consumption and emissions include the upstream stages, such as feedstock exploration, recovery, transportation, fuel production, in addition to the energy consumption and emissions occurring in the fuel utilization; but the facility construction is excluded for their little effect on the life cycle energy consumption and emission.
- **Non-fossil fuel to power:** 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

2. Calculation formula of energy consumption

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

$$EN_{PHEV} = \left[\sum_{k=1}^{i} E_{LC,k} * SH_k\right] * \frac{1}{1-\eta_{Loss}} * \frac{E_{Ele,PHEV}}{\eta_{Charge}} * \frac{3.6}{100} * SH_{Ele} + (1-SH_{Ele}) * E_{LC,Gasoline} * V_{Gasoline} * Q_{Gasoline} * \frac{1}{100}$$

- k: The type of power technologies from 1 to i mean: Coal, Oil, NG, Hydro, Nuclear, Solar, Wind ,Biomass, Geothermal, Others…
- SH_k: The share of type k in the total electricity supplying of regional electrical grids(%)
- $E_{LC,K}$: Life cycle energy consumption for electricity generation and supply of type k (MJ/MJ power supplying)
- η_{Loss}: Electricity transmission loss rate (%)
- η_{Charge}: Charging Efficiency (%)
- $E_{Ele,EV}$: Direct energy consumption of EV (kWh/100km) (kWh/100km)
- $E_{Ele,PHEV}$: Direct energy consumption of PHEV
- SH_{Ele}: The range share by electricity(%)
- 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

3. Calculation formula of GHG emissions

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

$$EM_{PHEV} = \left[\sum_{k=1}^{i} EM_{LC,k} * SH_k\right] * \frac{1}{1-\eta_{Loss}} * \frac{E_{Ele,PHEV}}{\eta_{Charge}} * \frac{3.6}{100} * SH_{Ele} + (1-SH_{Ele}) * EM_{LC,Gasoline} * V_{Gasoline} * Q_{Gasoline} * \frac{1}{100}$$

- k: The type of power technologies from 1 to i mean: Coal, Oil, NG, Hydro, Nuclear, Solar, Wind ,Biomass, Geothermal, Others…
- $EM_{LC,K}$: Life cycle GHG emission for electricity generation and supply of type k (g CO2, e/MJ power supplying)
- SH_k: The share of type k in the total electricity supplying(%)
- η_{Loss}: Electricity transmission loss rate (%)
- $E_{Ele,EV}$: Direct energy consumption of EV (kWh/100km) (kWh/100km)
- SH_{Ele}: The range share by electricity(%)
- $EM_{LC,\mathrm{Gasoline}}$: 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)
- η_{Charge}: Charging Efficiency (%)
- $E_{Ele,PHEV}$: Direct energy consumption of PHEV
- Q_{Gasoline}: Calorific value of gasoline (32 MJ/L)

Part 3: Operating manual

■ The model is based on EXCEL to get life cycle analysis results.

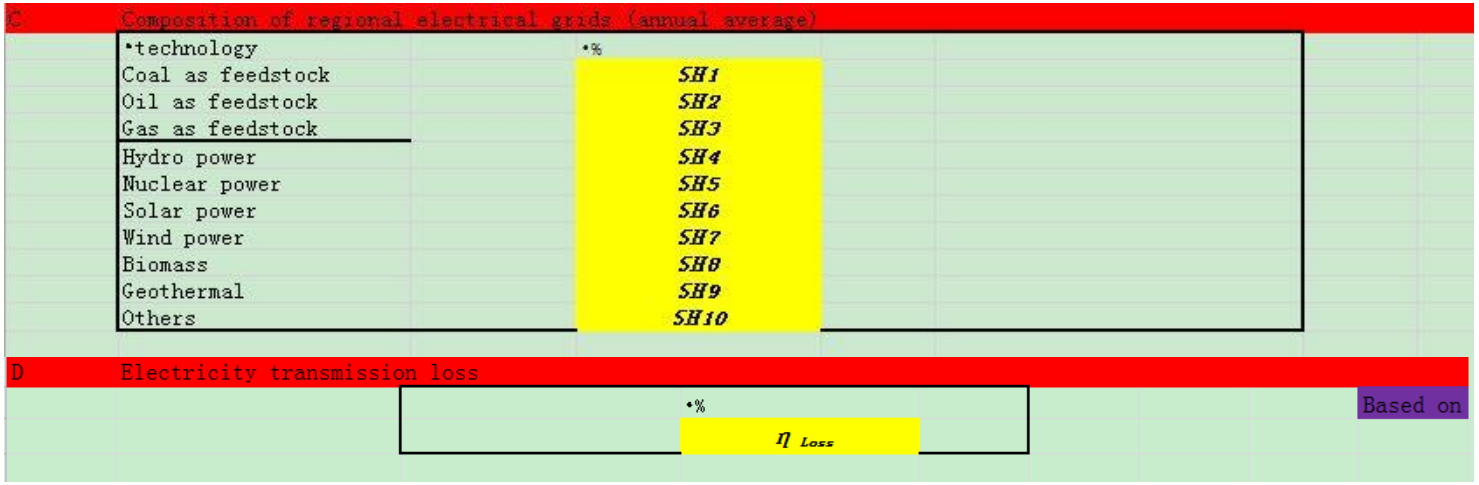
Based on the data of different regions and countries input in the Yellow Cell, the results will be showed in the output cell (the Green Cell) and the labelling is presented in the Orange Cell. The data is explained in the Purple Cell.

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

1. Upstream stage

B	Data for fossil and non-fossil fuel to power		
B. 1	•Life cycle energy consumption and GHG emissions situation for power generation and supplying		
	•technology	•MJ/MJ power supplying	•g CO2,e /MJ power supplying
	Coal as feedstock	$E_{LC,1}$	$EM_{LC,1}$
	Oil as feedstock	$E_{LC,2}$	$EM_{LC,2}$
	Gas as feedstock	$E_{LC,3}$	$EM_{LC,3}$
	Hydro power	$E_{LC,4}$	$EM_{LC,4}$
	Nuclear power	$E_{LC,5}$	$EM_{LC,5}$
	Solar power	$E_{LC,6}$	$EM_{LC,6}$
	Wind power	$E_{LC,7}$	$EM_{LC,7}$
	Biomass	$E_{LC,8}$	$EM_{LC,8}$
	Geothermal	$E_{LC,9}$	$EM_{LC,9}$
	Others	$E_{LC,10}$	$EM_{LC,10}$

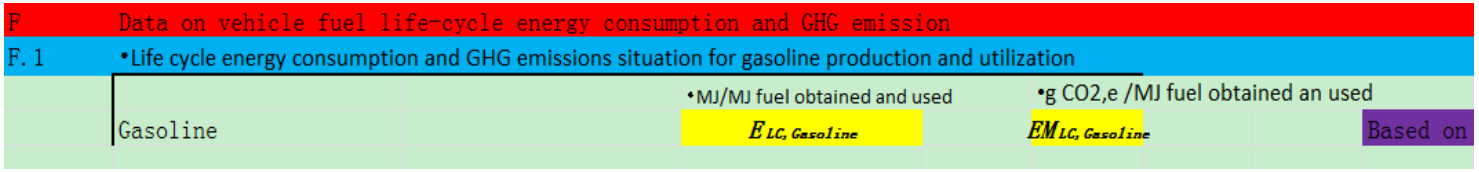
Part 3: Operating manual



C	Composition of regional electrical grids (annual average)		
	•technology	•%	
	Coal as feedstock	SH_1	
	Oil as feedstock	SH_2	
	Gas as feedstock	SH_3	
	Hydro power	SH_4	
	Nuclear power	SH_5	
	Solar power	SH_6	
	Wind power	SH_7	
	Biomass	SH_8	
	Geothermal	SH_9	
	Others	SH_{10}	
D	Electricity transmission loss		
		•%	Based on
		η_{Loss}	

- **2. Running stage**

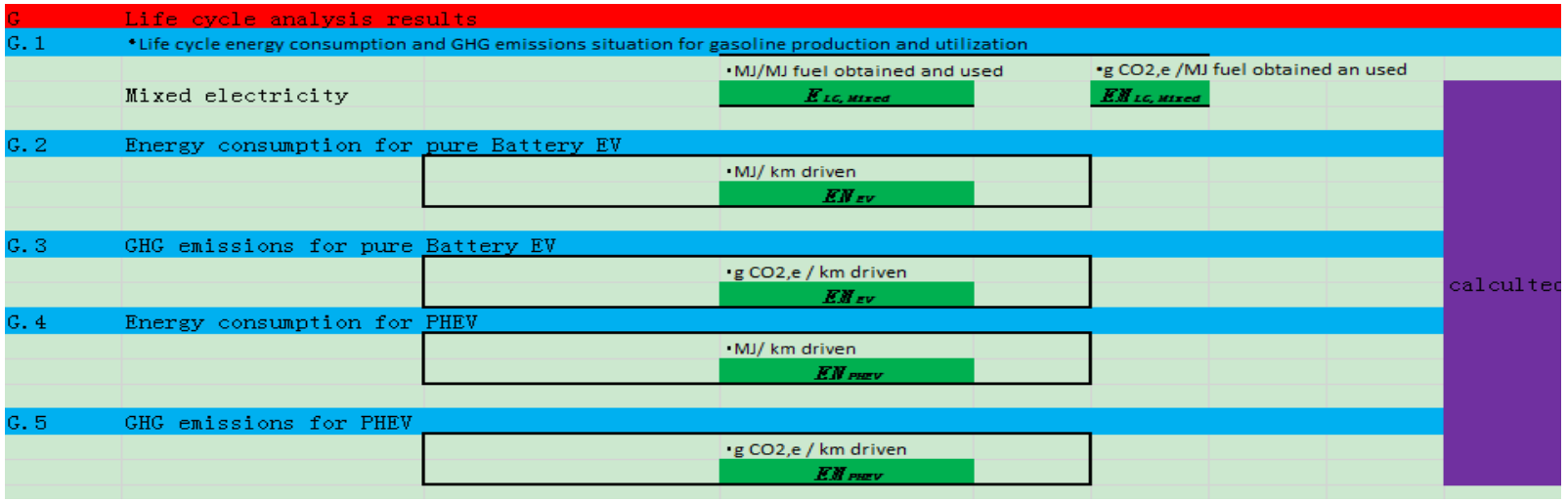
E	Data on EV charging and running				
E.1	Charging efficiency				Based on
		•%			
		η_{Charge}			
E.2	Energy consumption for	EV running			
		•kWh /100 km			Based on
		$E_{Ele,EV}$			
E.3	Energy consumption for	PHEV running			Based on
		•kWh /100 km	•liter /100 km	•Range share by el	
		$E_{Ele,PHEV}$	$V_{Gasoline}$	SH_{Ele}	

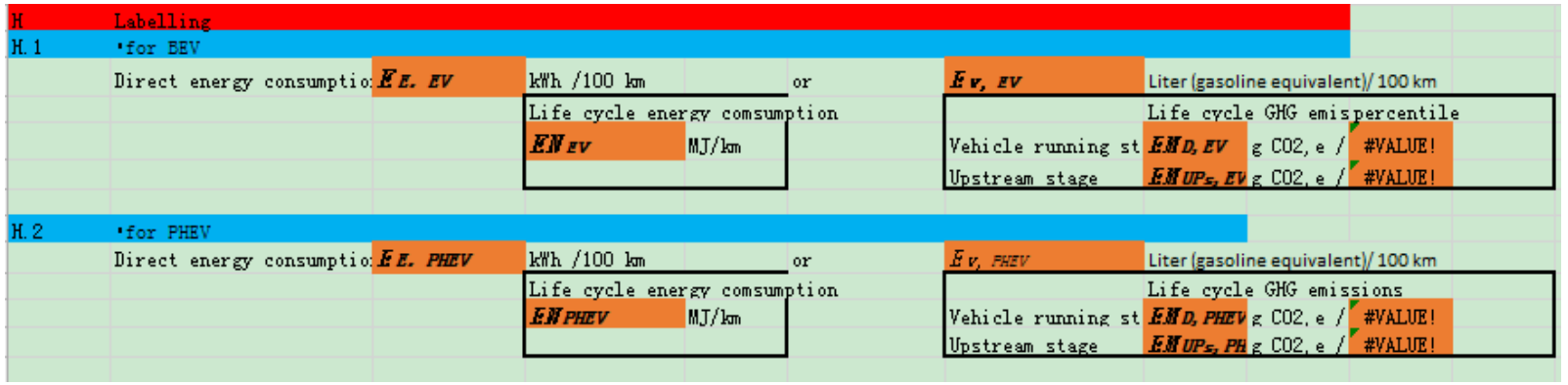


F	Data on vehicle fuel life-cycle energy consumption and GHG emission			
F.1	•Life cycle energy consumption and GHG emissions situation for gasoline production and utilization			
		•MJ/MJ fuel obtained and used	•g CO2,e /MJ fuel obtained an used	
	Gasoline	$E_{LC,Gasoline}$	$EM_{LC,Gasoline}$	Based on

Part 3: Operating manual

- **3. Calculation result**





Part 4: Data to collect

1. **Data on electricity chains**
   - Life cycle energy consumption and GHG emissions situation for fossil and non-fossil fuel power generation and supplying (Coal, Oil, Gas, Hydro, Nuclear, Solar, Wind, Biomass, Geothermal and others)
     - MJ/MJ power supplying
     - g CO2,e /MJ power supplying
   - Composition of regional electrical grids (Coal, Oil, Gas, Hydro, Nuclear, Solar, Wind, Biomass, Geothermal and others, %)
   - Electricity transmission loss (%)
2. **Data on EV/PHEV charging and running**
   - Charging efficiency (%)
   - Energy consumption for EV 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. Comparing energy consumption by primary energy
   - ** MJ / km
3. Comparing GHG emissions to conventional gasoline vehicle
   - Total
   - By stages

Calculation with the model

- The data of electricity mix and upstream emissions factor of different power supplying have been collected in some countries and regions(China ,USA ,EU , Japan and Canada) from literature review ,statistical book and formal report.
- The GHG emissions intensity of a power generation mix is calculated based on the database and the model. The value is the average amount of GHG emissions per unit of electrical energy generated by all of the power production processes in a mix weighted by the amount of power obtained from each of those processes.
- Direct energy consumption of EVs is assumed in the model to calculate and assess the GHG emissions of the same EV in China, USA, EU, Japan and Canada. The actual value should in accordance with the research result of WLTP.
- The database and the results of the calculation are shown in the model. And then it will be introduced in the following presentation.

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. The data format please see Appendix I in the report document.
- Modifications suggestion for our suggested methods, with the presentation about the experiences of current calculation and labelling methods in EU, US and other specific regions.

Thanks