Issues and suggestion of Annex 57 project report and guidelines

(S): Tentative suggestion and comments by T. Oka

1. Purpose of Project Report

(S) After review of the existing research results related to EEC, lacked and necessary research tasks should be compensated. The report shows ***calculation and evaluation methods with effective measures to reduce EEC*****.**

2. Purpose of Guidelines

(S) The relevant and practical ***calculation and evaluation methods should be shown to users with global image, case studies and the information sources*** of EEC. The criterion of judgment for users concerning EEC should be provided.

3. Definition of EEC

Embodied Energy: Embodied energy is the total amount of ***non-renewable primary energy*** required for all direct and indirect processes related to the creation of the building, its maintenance and end-of-life. In this sense the forms of embodied energy consumption include the energy consumption for the initial stages, the recurrent processes and the end of life processes of the building.

Embodied GHG emissions: Embodied GWP is the ***cumulative quantity of greenhouse gases*** (CO_2, methane, nitric oxide, and other global warming gases), which are produced during the direct and indirect processes related to the creation of the building, its maintenance and end-of-life. This is expressed as *CO_2 equivalent* that has the same greenhouse effect as the sum of GHG emissions.

RE: (S) Annex 57 will deal with ***CO_2 and Freon gases*** since the influence of other GHGs are negligible for EEC due to building construction. The rate of renewable energy in material production process seems to be difficult to take into account EEC.

4. Boundary condition

4.1 Electricity: (S) Although electricity is imported and exported between countries and partly produced by renewable energy, the primary energy to produce 1kW of electricity is energy consumption of fossil fuels in the interested state. Therefore the influence of import/export and renewable energy is ignored in Annex 57. But Problem is the definition of ***primary energy of electricity produced by nuclear power.***

4.2 Construction material: (S) Since the coefficients of energy/CO_2 in DB are usually based on the energy consumption assuming that the material is produced in the interested state, ***the boundary condition is the national border***. Moreover it is difficult to estimate EEC of imported material. When EEC of imported material is used specially, it should be clearly defined and described.

5. Global image of EEC

(S) EEC of Asian countries are more than operational energy/CO_2, which is ***quite different*** from European countries. EEC should be shown country by country at the beginning and it is also necessary to find out effective measures for Asia countries such as technology transfer from developed countries to developing countries to reduce EEC in the world. EEC per capita is also another index to show EEC, for example the largest EEC per capita is Canada.

6. Database (DB)

6.1 EEC coefficients of Recycle Materials and CO2 Credit

Few data bases show EEC of recycled materials. ***Recycle CO2 credit*** has not been discussed yet in Annex 57.

(1) Steel

Generally rebar is recycled steel produced by ***electrical furnace*** and shaped steel is virgin steel by ***converter furnace***. But world steel association suggested not to divide recycle and virgin steel because scrap iron is 100% recycled now. Moreover assuming that scrap iron will increase in future, it suggests that EEC of steel should be reduced in advance taking into account the recycle effect in future, that is recycle CO2 credit of steel.

(S) EEC of steel is better to be unified in Annex 57. User can use recycle CO2 credit, if the policy intends the increase of recycled materials, under the condition that the value of the recycle CO2 credit is differentiated and described clearly.

(2) Concrete

Recycled concrete means generally concrete with fly-ash and blast-furnace slag cement. Waste concrete from building demolition site is used for road and pavement as recycled concrete in the field of civil engineering.

(S) Recycled concrete is concrete with ***fly-ash and blast-furnace slag cement*** in Annex 57. There are EECs of these recycled concrete in Japan.

(3) Aluminum

For instance, since aluminum in Japan is produced from both imported ingot and recycled aluminum products, energy to produce ingot is ignored, and EEC of aluminum is energy for casting and rolling.

(S) Energy to produce ***ingot can be ignored***, because energy to produce ingot is impossible to estimate.

(4) Wood

Since wood can be burned to produce energy at the end of use for building, thermal recycle credit can be applied.

(S) User can use ***recycle CO2 credit*** if the policy intends the increase of use of wood, under the condition that the value of recycle CO2 credit is differentiated and described clearly.

6.2 EEC DB for machines and facilities

There is no EEC of machines and facilities in databases which are based on process survey.

(S) These EEC can be obtained from ***ecoinvent and IO*** analysis.

6.3 Data of EPD seems to be excellent. But are there sufficient terms to calculate EEC of building?

6.4 Feedstock energy of materials

(S) It is important point of view. But it seems to be difficult to differentiate the feedstock energy from total energy consumption when materials are produced. For instance, formed insulation of 1kg consists of combustion of 1kg oil and feedstock of 1kg oil. Wood is 14.4MJ/kg-wood. ***Feedstock energy of materials should be involved in EEC*** and not differentiated in Annex 57

7. Calculation method

Guidelines for Design Professionals & Consultants by TL and MB show excellent framework and information provision. But there are still some issues as follows.

7.1 Early design stage: The terms to be calculated should be defined. Otherwise user can not start to calculate EEC.

(S) The following table is suggested for office and commercial building. ***Less number of items is better***. PV should be added to single family house

Table 7-1 Example to calculate EEC of the building at early design stage

Plan	Material/Component		Unit (A)	EEC Unit (B)	Mainte-nance	Number of Times of Replacement (C)	Demolition (D)	Total (AxBxC)
Items	Concrete	Pile	m^3	$/m^3$	0 MJ 0 kg-CO2	None	Demolition & Waste Treatment (Unit: EEC/m^2)	
		Column	m^3					
		Beam	m^3					
		Wall (Concrete)	m^3					
		Wall (Light Concrete)	m^3					
		Floor	m^3					
	Steel	Pile	t	/t		None		
		Column	t					
		Beam	t					
		Wall (Concrete)	t					
		Wall (Light Concrete)	t					
		Floor	t					
	Outer Surface Material	Metal	t	/t		Every 30 years		
		Ceramics	m^3	$/m^3$				
	Window	Glass	m^3	$/m^3$		Every 30 years		
		Frame	kg	/kg				
	Insulation	Insulation Material	m^3	$/m^3$		Every 20 years		
		Freon gasses	kg	/kg				
	Wood	–	m^3	$/m^3$		Every 30 years		
	HVAC	Central Refrigerator	kW	/kW		Every 15 years		
		Individual Refrigerator	kW	/kW				
		Freon gasses	kg	/kg				
	Electric Facilities	Elevator/Escalator	kW	/kW		Every 20 years		
		Transformer	kW	/kW				
	New Materials	–	Euro	/Euro		Every 15 years		
	Construction Site	Electricity & Oil	m^2	$/m^2$		None		
Total								Σ (AxBxC) +D

Table 7-2 Ecoinvent (Characteristic material composition of a multi-storey building (Mauch et. Al(1995))

Material-Input	[%] (v/v)	Modelled as	Construction phase [kg/m³]	Refurbishment [kg/m³]	Total [kg/m³]
Reinforced Concrete[5]	31	Concrete (97 %)	231.86	0.00	231.86
		Reinforcement steel (3 %)	7.17	0.00	7.17
Brick	48	Brick	177.66	0.00	177.66
Mortar	5	Mortar	30.84	30.84	61.69
Glass	0.2	Glass	1.54	1.54	3.08
Wood	10	Wood	15.42	15.42	30.84
Metals	2	Steel (1%)	16.96	0.00	16.96
		Aluminium (0.5%)	8.48	0.00	8.48
		Copper (0.5%)	8.48	0.00	8.48
Insulation	3	Rock-wool	0.65	0.65	1.30
Plastics	0.4	PVC	0.46	0.46	0.93
Others	0.4	PE	0.46	0.46	0.93
Total	100		500	95	600

7.2 BIM

If the designer uses BIM, the quantity of concrete can be estimated but not steel inside concrete. The limitation of BIM should also be shown. Since BIM is quite difficult to use now, it may be distant to use BIM only for EEC.

(S) ***Statistical data of concrete and steel*** should be provided so that designers can estimate EEC of the building at early design stage. The increment of the quantity of concrete and steel is proportional to increment of structural strength in the countries where earthquake happens. It is also directly linked to the building life.

Table 7-3 Statistical data of concrete and steel used in buildings

a. Quantity of concrete (%)

	Foundation	Column	Beam	Wall	Floor
Bent(Rigit frame)	23	9	22	19	27
Wall structure	20	0	4	41	35

b. Quantity of concrete (m^3/m^2)

Office (Bent)			Total Floor Area (m^2) =F					
Story	Material	Unit	F<200	200<F<500	500<F<1000	1000<F<2000	2000<F<3000	3000<F
2	Concrete	m^2	0.70	0.69	0.69	0.68	0.67	0.66
	Form work	m^2	8.29	7.95	7.62	7.29	6.96	6.63
	Steel	t	0.114	0.114	0.116	0.119	0.121	0.123
4	Concrete	m^2	0.68	0.67	0.66	0.66	0.65	0.64
	Form work	m^2	8.12	7.79	7.47	7.14	6.82	6.50
	Steel	t	0.125	0.125	0.128	0.130	0.133	0.135
6	Concrete	m^2	0.66	0.65	0.64	0.64	0.63	0.62
	Form work	m^2	7.95	7.63	7.32	7.00	6.68	6.36
	Steel	t	0.137	0.137	0.140	0.142	0.145	0.148

c. Quantity of steel (t/m^2)

Office (Bent) : S			Total Floor Area (m^2) =F					
Story	Material	Unit	F<200	200<F<500	500<F<1000	1000<F<2000	2000<F<3000	3000<F
1	Steel	t	0.154	0.154	0.154	0.154	0.154	0.154
2			0.169	0.169	0.169	0.169	0.169	0.169
3			0.184	0.184	0.184	0.184	0.184	0.184
4			0.193	0.193	0.193	0.193	0.193	0.193
5			0.204	0.204	0.204	0.204	0.204	0.204

Floor height (FH) = 4m<FH<5m

7.3 Pile: EEC of concrete and steel for piles often reaches more than 30% of whole EEC of the building.

(S) ***Simple calculation method*** should be provided with various types of pile.

7.4 EEC of machines: EEC of machines and facilities are not able to be estimated by the weight multiplied by EEC coefficient.

(S) ***EEC per kW*** (output of the machine) can be used instead of the weight, and ecoinvent as well as DBs based on IO analysis can be used.

7.5 Freon gases

Description regarding Freon gases is necessary. Some type of foamed insulation and electrical refrigerator use Freon gases.

(S) Simple calculation method should be provided. Freon gases involved ***in insulation*** is released and replaced by air within 10 years, which means Freon gases do not contribute to improve the efficiency of the insulation. The quantity of Freon gases ***in refrigerator*** is proportional to the capacity, which means it is possible to reduce Freon gases by downsizing of the refrigerator. It can be realized by low energy building and absorption refrigerator may be an option. Information concerning Freon gases would be useful for clients and should be written in guidelines.

7.6 Transportation: (S) It is possible to estimate EEC by World IO analysis as average value. But transportation for import is excluded. Definition of transport is ***from gate factory to construction site***.

7.7 EEC of demolition: Most of EEC for demolition and treatment of waste materials is transportation.

(S) EEC of demolition is defined by ***the total weight of the building x distance x EEC of transportation*** *(MJ/t.km).*

7.8 Long life building

Grounds for long life building should be described.

(S) For instance, in case of Japan, the quakeproof strength of the long life building increases by 25%-30% than the regulation, the covering depth of rebar is 2cm more than the regulation and the pipes are corrosion control.

7.9 Guidelines seem to focus on the tools too much.

(S) Simple calculation method by hand should be suggested because the guidelines are supposed to be used mainly by designers/ consultants at early design stage.

8. Measures to reduce EEC

Measures: There are a lot of measures but practitioners may not know which measures are effective to reduce EEC.

(S) How about to recommend that ***(1) long life building, (2) reduction of Freon gases, (3) use of recycle and natural materials and (4) retrofit of existing building*** are most effective measures to reduce EEC? To narrow the focus seems to be important in Annex 57. Each calculation method should be described simply so that designers/consultants can estimate the reduction of EEC while they are designing.

8.2 Measures to reduce EEC at construction site should be described. Usually it is approximately 5% but more than 20% in Canada.

(S) ***Statistical data*** of energy consumption at construction site should be shown in tables.

8.3 Guidelines for manufacturers: How about to request manufacturers to produce construction materials to contribute long life building, and insulation materials and machines without Freon gases?

9. Evaluation

9.1 LCA or profile of energy/CO2 emissions: ***LCA*** seems to be addressed too much. The ***energy/CO2 emissions profile*** of the country is important from the practical view point and for policy makers. It seems to be easier to understand the effect of EEC reduction.

(S) Profile of energy/CO2 emissions should be provided as many as possible.

9.2 Quantity of materials used in building: EEC is difficult to understand by the senses. The ***weight of the materials*** is easier to understand as the feeling.

(S) It is necessary to provide statistical data of quantity of materials used in buildings so that designers/consultants are able to understand the EEC performance of the building under design by comparing with the statistical data. Statistical data in various countries should be collected as many as possible.

9.3 Open case study: If the data of case studies are input in ***the template for open case study***, designers/consultants/policy makers can trace and estimate the EEC of their buildings by replacing their data in the template.

9.4 Input to rating system and EPD: Evaluation only by EEC seems to be difficult to disseminate. The calculation method of EEC can be applied simply to EPD. For instance, how about the possibility to express the ***building with one value of EPD in future***? Generally existing rating systems seem to focus mainly on the operation energy/CO_2, which is improper especially for Asian countries.

9.5 Construction cost: It seems to be important and should not be ignored.