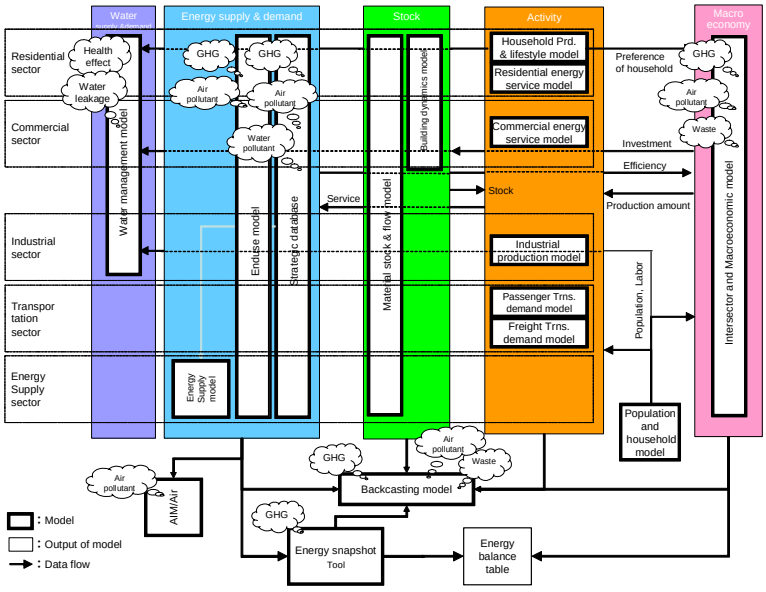
Manual

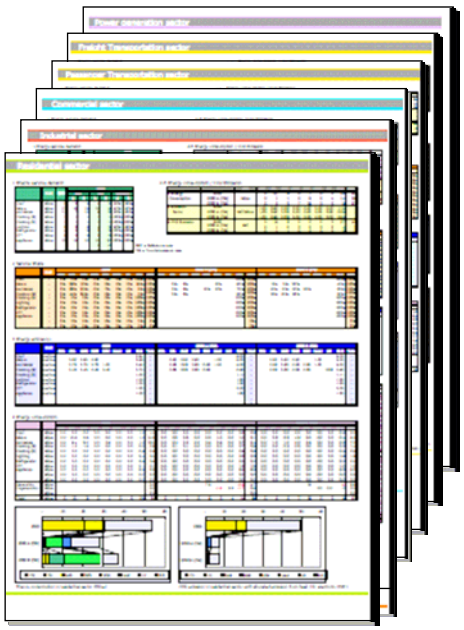
Energy Snapshot tool (ESS)

Asia-Pacific

AIM

Integrated Model





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November 2006

Content

1. What is ESS?

1.1 Characteristics of ESS

The Energy SnapShot tool (ESS) is developed on the spreadsheet as shown in Fig. 1.1. Giving service demand, share of energy and energy improvement by classification of service and energy in the base year and the target year, the tool calculates the energy balance table and the energy balance table and the CO_2 emission table immediately with keeping consistency among sectors.

Since users can conduct sensitivity analysis with different parameters promptly, the model is suitable for the communication among stakeholders to design low carbon society. Besides, the model can be used as a simple assessment tool of output from various models.

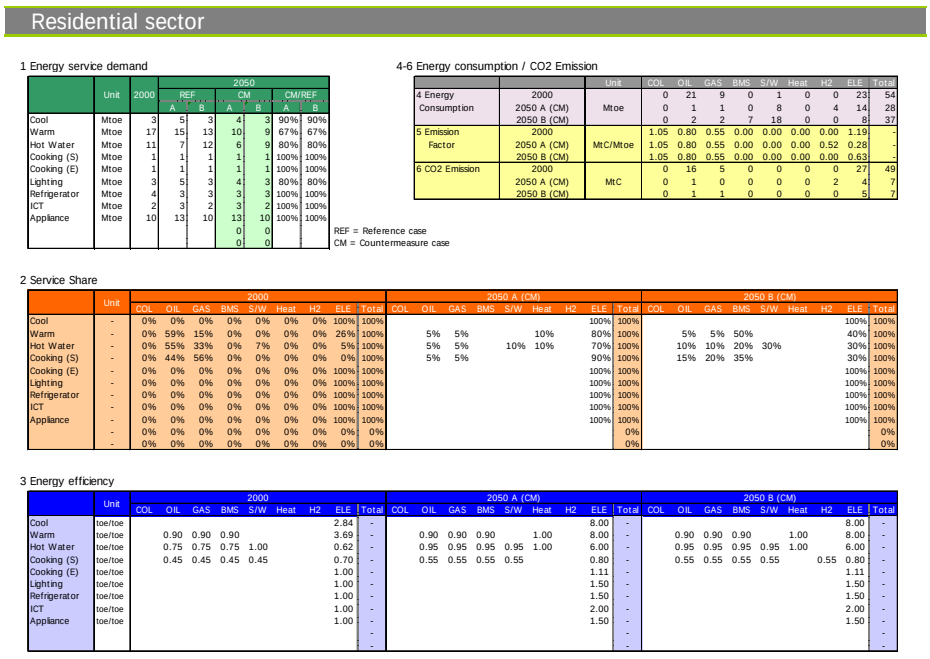

Fig. 1.1 ESS (partly, Residential sector)

1.2 Structure of ESS

ESS is comprised of the worksheets as shown in Table 1.1. The relationship among the worksheets is shown in Fig.1.2.

Table 1.1 Worksheets of ESS

Worksheet	Content
Title	Cover of ESS
CTL	Enter unit, simulation year, scenario name and CO_2 emission factor
IND	Develop energy flow in industrial sector
RES	Develop energy flow in residential sector
COM	Develop energy flow in commercial sector
TR_P	Develop energy flow in passenger transportation sector
TR_F	Develop energy flow in freight transportation sector
PWR	Develop energy flow in power generation sector
TTL_SD	Develop energy balance table in both energy enduse sector and energy transformation sector.
TTL_S	Develop energy balance table with countermeasures in energy enduse sector for factors analysis of CO_2 reduction.
TTL_D	Develop energy balance table with countermeasures in energy transformation sector for factors analysis of CO_2 reduction.
TTL_0	Develop energy balance table without countermeasure in both energy enduse sector and energy transformation sector for factors analysis of CO_2 reduction.
Factors	Factors analysis of CO_2 reduction is shown.
EneEms	Graphs of energy consumption and CO_2 emission are shown.

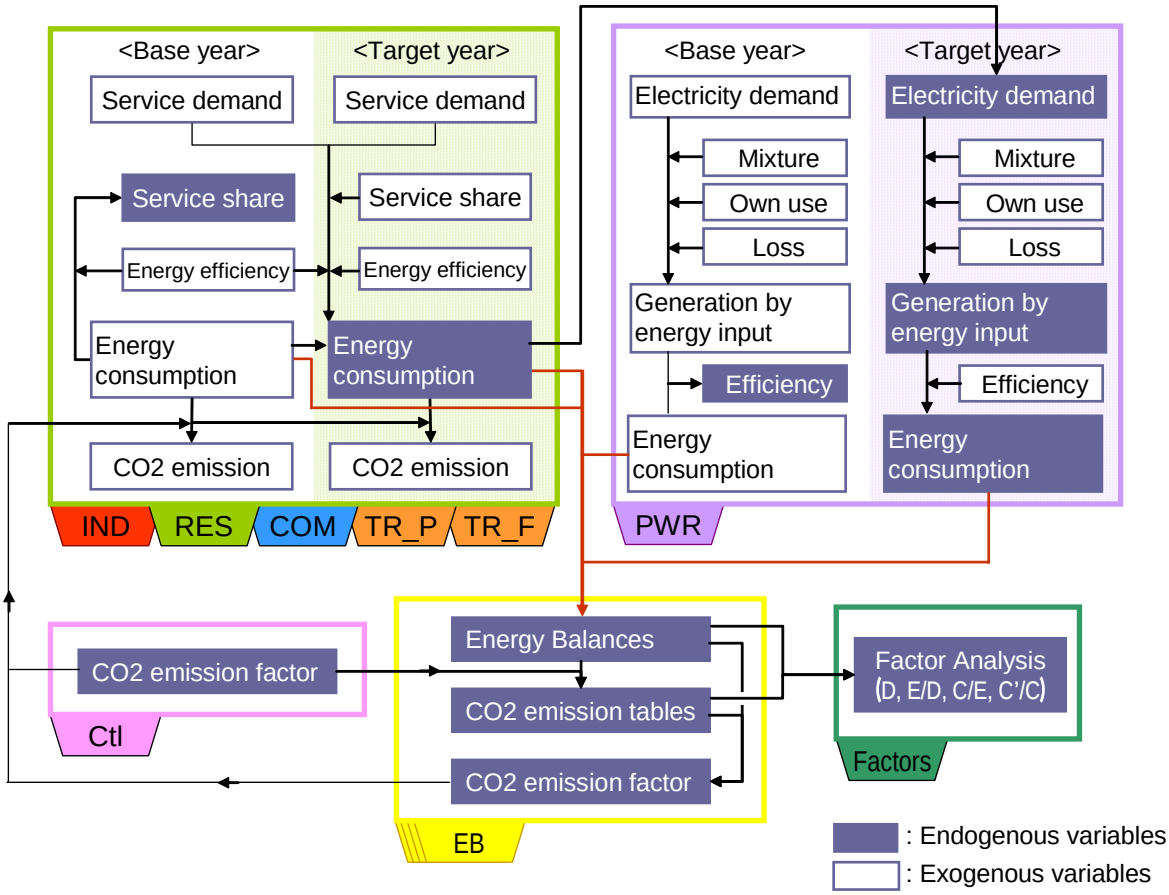

Fig.1.2 Relationship among the worksheet in ESS

1.3 ESS Software

1.3.1 System requirement

MS Excel must be installed in your PC for execution of ESS.

1.3.2 ESS Software

(ESS can be downloaded from the following website.)not yet

http://2050.nies.go.jp

The ZIP file includes the following files.

- ESS_JPN.xls : Energy balance in Japan

2. How to use ESS

This chapter shows the procedure of entering data on each worksheet.

Users enter values in white cells for development of energy balances and CO2 emission table. The values in colored cells are shown automatically.

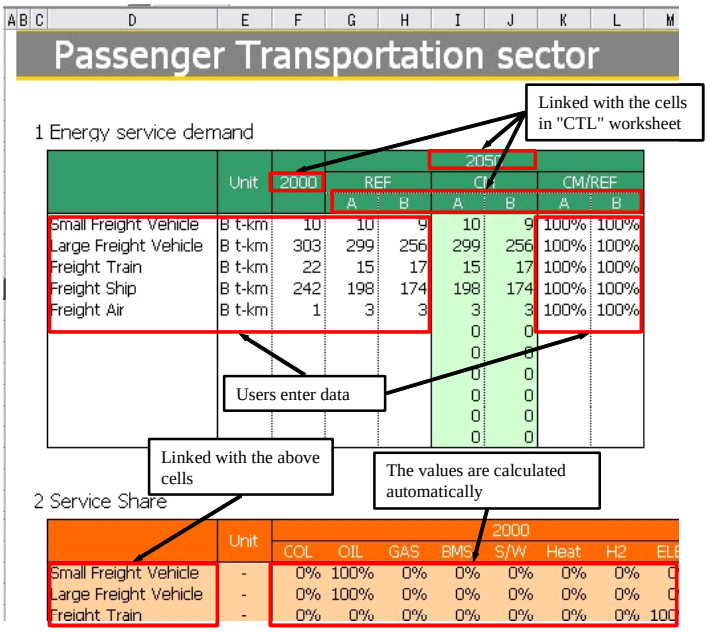

Fig. 2.1 White cell and colored cell

2.1 CTL

Enter the cell of the following items in the “CTL” worksheet.

- Unit: Energy, CO_2
- Simulation year: Base year, Target year
- Scenario name: Scenario 1, Scenario 2
- Emission Factor: COL, OIL, GAS, BMS, NUC, HYD, S/W

COL = Coal and coal products

OIL = Crude oil and oil products

GAS = Natural gas

BMS = Biomass

NUC = Nuclear

HYD = Hydro

S/W = Solar, Wind, Tide

2.2 IND, RES, COM, TR_P, TR_F

Energy consumption and CO2 emission in energy enduse sectors are calculated in these worksheets. The “IND” worksheet corresponds to industrial sector, “RES” residential sector, “COM” commercial sector, “TR_P” passenger transportation sector, “TR_F” freight transportation sector. The structures in the worksheets are same. The explanation of each table in the worksheet is shown as follows.

1. Energy service demand

   Enter service demand in the base year and the target year in the table. The year and the name of scenarios are shown automatically with linkage of input in the “CTL” worksheet.

1 Energy service demand

	Unit	2000	2050					
			REF		CM		CM/REF	
			A	B	A	B	A	B
Cool	Mtoe	3	5	3	4	3	90%	90%
Warm	Mtoe	17	15	13	10	9	67%	67%
Hot Water	Mtoe	11	7	12	6	9	80%	80%
Cooking (S)	Mtoe	1	1	1	1	1	100%	100%
Cooking (E)	Mtoe	1	1	1	1	1	100%	100%
Lighting	Mtoe	3	5	3	4	3	80%	80%
Refrigerator	Mtoe	4	3	3	3	3	100%	100%
ICT	Mtoe	2	3	2	3	2	100%	100%
Appliance	Mtoe	10	13	10	13	10	100%	100%
					0	0		
					0	0		

Fig. 2.2 “Energy service demand” table in ESS

Table 2.1 Contents of “Energy service demand” table

Column	Contents
D	Type of energy service. After entering
E	Unit of energy service demand
F	Energy service demand in the base year
G, H	Energy service demand of reference case in a target year. The reference case does not consider effects of measure that decreases the demand.
I*, J*	Energy service demand of countermeasure case in a target year. The countermeasure case does not consider effects of measure that decreases the demand. = G*K, = H*L
K, L	Ratio of service demand of the countermeasure case to that of the reference case.

*: The data in the column is shown automatically.

2. Service share

   Enter service share in target year in the table. The service share in the base year is calculated based on the following formulation.

$$SS(s,e) = \frac{EC(s,e) \times EE(s,e)}{\sum_{e} EC(s,e) \times EE(s,e)}$$

SS: Service share

EC: Energy consumption

EE: Energy efficiency

s: Service, *e*: Energy

2 Service Share

	Unit	2000									2050 A (CM)									2050 B (CM)								
		COL	OIL	GAS	BMS	S/W	Heat	H2	ELE	Total	COL	OIL	GAS	BMS	S/W	Heat	H2	ELE	Total	COL	OIL	GAS	BMS	S/W	Heat	H2	ELE	Total
Cool	-	0%	0%	0%	0%	0%	0%	0%	100%	100%								100%	100%								100%	100%
Warm	-	0%	59%	15%	0%	0%	0%	0%	26%	100%		5%	5%			10%		80%	100%		5%	5%	50%					40%	100%
Hot Water	-	0%	55%	33%	0%	7%	0%	0%	5%	100%		5%	5%		10%	10%		70%	100%		10%	10%	20%	30%				30%	100%
Cooking (S)	-	0%	44%	56%	0%	0%	0%	0%	0%	100%		5%	5%					90%	100%		15%	20%	35%					30%	100%
Cooking (E)	-	0%	0%	0%	0%	0%	0%	0%	100%	100%								100%	100%									100%	100%
Lighting	-	0%	0%	0%	0%	0%	0%	0%	100%	100%								100%	100%									100%	100%
Refrigerator	-	0%	0%	0%	0%	0%	0%	0%	100%	100%								100%	100%									100%	100%
ICT	-	0%	0%	0%	0%	0%	0%	0%	100%	100%								100%	100%									100%	100%
Appliance	-	0%	0%	0%	0%	0%	0%	0%	100%	100%								100%	100%									100%	100%
	-	0%	0%	0%	0%	0%	0%	0%	0%	0%									0%									0%	0%
	-	0%	0%	0%	0%	0%	0%	0%	0%	0%									0%									0%	0%

Fig. 2.3 “Service share” table in ESS

Table 2.2 Contents of “Service share” table

Column	Contents
D*	Type of energy service.
F* ~ N*	Service share in the base year.
O ~ W	Service share of scenario 1 in the target year.
X ~ AF	Service share of scenario 2 in the target year.

*: The data in the column is shown automatically.

3. Energy efficiency

Energy efficiency is the ratio of service output to energy input. Enter energy use efficiency in base year and target year in the table.

3 Energy efficiency

	Unit	2000									2050 A (CM)									2050 B (CM)								
		COL	OIL	GAS	BMS	S/W	Heat	H2	ELE	Total	COL	OIL	GAS	BMS	S/W	Heat	H2	ELE	Total	COL	OIL	GAS	BMS	S/W	Heat	H2	ELE	Total
Cool	toe/toe								2.84	-								8.00	-								8.00	-
Warm	toe/toe		0.90	0.90	0.90				3.69	-		0.90	0.90	0.90		1.00		8.00	-		0.90	0.90	0.90		1.00		8.00	-
Hot Water	toe/toe		0.75	0.75	0.75	1.00			0.62	-		0.95	0.95	0.95	0.95	1.00		6.00	-		0.95	0.95	0.95	0.95	1.00		6.00	-
Cooking (S)	toe/toe		0.45	0.45	0.45	0.45			0.70	-		0.55	0.55	0.55	0.55			0.80	-		0.55	0.55	0.55	0.55		0.55	0.80	-
Cooking (E)	toe/toe								1.00	-								1.11	-								1.11	-
Lighting	toe/toe								1.00	-								1.50	-								1.50	-
Refrigerator	toe/toe								1.00	-								1.50	-								1.50	-
ICT	toe/toe								1.00	-								2.00	-								2.00	-
Appliance	toe/toe								1.00	-								1.50	-								1.50	-
										-									-									-
										-									-									-

Fig. 2.4 “Energy efficiency” table in ESS

Table 2.3 Contents of “Energy efficiency” table

Column	Contents
D*	Type of energy service.
E	Unit of energy use efficiency
F ~ M	Energy use efficiency in the base year.
O ~ V	Energy use efficiency of scenario 1 in the target year.
X ~ AE	Energy use efficiency of scenario 2 in the target year.

*: The data in the column is shown automatically.

Table 2.4 Example of unit of energy use efficiency (Japan case)

Sector		Unit
Residential & Commercial	Cool, Warm – Heat pump	Coefficient of performance
Residential & Commercial	Warm, Cooking - Stove	Heat efficiency
Residential & Commercial	Others	2000’s efficiency = 1.00
Industrial		2000’s efficiency = 1.00
Transportation		2000’s efficiency = 1.00

4. Energy consumption

Enter energy consumption in base year in the table. The energy consumption in the target year is calculated based on the following formulation.

$$EC(s,e)=\left(\sum_{e} EC_0(s,e)\times EE_0(s,e)\right)\times\frac{S(s)}{S_0(s)}\times SS(s,e)\div EE(s,e)$$

SS: Service share

EC: Energy consumption

EE: Energy efficiency

$_0$: Base year

s: Service, *e*: Energy

Users enter energy transformation in each sector in the lower part of the table. Energy flow of electricity and heat generation by photovoltaic and cogeneration is shown here. Energy input is entered with (+), energy output is entered with (-).

4 Energy consumption

		2000									2050 A (CM)									2050 B (CM)								
		COL	OIL	GAS	BMS	S/W	Heat	H2	ELE	Total	COL	OIL	GAS	BMS	S/W	Heat	H2	ELE	Total	COL	OIL	GAS	BMS	S/W	Heat	H2	ELE	Total
Cool	Mtoe	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.3
Warm	Mtoe	0.0	10.9	2.8	0.0	0.0	0.0	0.0	1.2	14.9	0.0	0.5	0.5	0.0	0.0	1.0	0.0	1.0	3.1	0.0	0.5	0.5	4.9	0.0	0.0	0.0	0.4	6.3
Hot Water	Mtoe	0.0	8.4	5.0	0.0	0.8	0.0	0.0	1.0	15.2	0.0	0.3	0.3	0.0	0.6	0.6	0.0	0.7	2.4	0.0	1.0	1.0	2.0	2.9	0.0	0.0	0.5	7.3
Cooking (S)	Mtoe	0.0	1.2	1.6	0.0	0.0	0.0	0.0	0.0	2.8	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.7	0.8	0.0	0.2	0.3	0.5	0.0	0.0	0.0	0.3	1.4
Cooking (E)	Mtoe	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.6
Lighting	Mtoe	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.4	3.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.5	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8	1.8
Refrigerator	Mtoe	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.6	3.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.2	2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.2	2.2
ICT	Mtoe	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.1	2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0
Appliance	Mtoe	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.9	9.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.9	8.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.5	6.5
	Mtoe	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Mtoe	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Generation	Mtoe									0.0					7.6			-2.9	4.7					16			-6	9.6
Cogeneration	Mtoe									0.0						-1.6	3.9	-1.7	0.6						0.0	0.0	0	0.0
	Mtoe									0.0									0.0									0.0
Total	Mtoe	0	21	9	0	1	0	0	23	54	0	1	1	0	8	0	4	14	28	0	2	2	7	18	0	0	8	37

Fig. 2.5 “Energy consumption” table in ESS

5. Emission Factor

The emission factors are shown automatically. The factors of coal, oil, gas, biomass are linked with the value in the “CTL” sheet. The factors of electricity and hydrogen are linked with the value in the “TTL_SD” sheet.

6. CO_2 Emission

The CO_2 emissions in the base year and the target year are shown automatically. The CO_2 emissions are calculated based on the following formulation.

$$CO2(e) = EC(e) \times EF(e)$$

CO_2: CO_2 emission

EC: Energy consumption

EF: CO_2 emission factor

e: Energy

4-6 Energy consumption / CO2 Emission

		Unit	COL	OIL	GAS	BMS	S/W	Heat	H2	ELE	Total
4 Energy Consumption	2000	Mtoe	0	21	9	0	1	0	0	23	54
	2050 A (CM)		0	1	1	0	8	0	4	14	28
	2050 B (CM)		0	2	2	7	18	0	0	8	37
5 Emission Factor	2000	MtC/Mtoe	1.05	0.80	0.55	0.00	0.00	0.00	0.00	1.19	-
	2050 A (CM)		1.05	0.80	0.55	0.00	0.00	0.00	0.52	0.28	-
	2050 B (CM)		1.05	0.80	0.55	0.00	0.00	0.00	0.00	0.63	-
6 CO2 Emission	2000	MtC	0	16	5	0	0	0	0	27	49
	2050 A (CM)		0	1	0	0	0	0	2	4	7
	2050 B (CM)		0	1	1	0	0	0	0	5	7

Fig. 2.6 “Energy consumption”, “Emission factor”, “CO2 emission“ table in ESS

2.3 PWR

This sheet calculates electricity generation and energy consumption in power generation sector under the condition that electricity demand in enduse sector is equal to electricity supply in power generation sector. The solver can match electricity demand and supply automatically. The tables in a target year are four types as follows.

- Supply and demand: Considering countermeasures in both enduse sector and energy transformation sector.

- Only demand: Considering countermeasures in only enduse sector.
- Only Supply : Considering countermeasures in only energy transformation sector.
- No : Considering no countermeasures.

“Only demand”, “Only demand”, “No” table is for factor analysis of CO2 reduction. The data in the three table is calculated automatically.

The explanation of each table is shown as follows.

1. Electricity demand at receiver end

Total electricity demand of all the sectors. Enter the value in the base year. The value in a target year is linked with the summation of electricity consumption in the summarized sheet (TTL_SD, TTL_D, TTL_S, TTL_0).

2. Difference between demand and supply

Difference between electricity demand at receiver end (10^{th} line) and electricity supply (18^{th} line). The solver whose command button is located at [5,F] decides electricity supply under the condition that the difference is zero. If the value in this table is not zero, click the solver button.

3. Electricity supply at receiver end

3-1. Electricity supply

Electricity supply at receiver end. The values are shown based on the following formulation.

Electricity supply at receiver end

= Electricity supply before transmission (4-1) x (1-Tranmission loss(3-2))

3-2. Transmission loss

Transmission loss factor between electricity supplier and receiver. Enter the value in a base year and a target year.

Power generation sector

Solver

		2000	2050							
			Supply & Demand		Only Demand		Only Supply		No	
			A	B	A	B	A	B	A	B
1. Electricity demand at receiver end										
	Mtoe	72	62	44	62	44	88	71	88	71
2. Difference between demand and supply										
	Mtoe	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3. Electricity supply at receiver end										
Electricity supply	Mtoe	72	62	44	62	44	88	71	88	71
Transmission Loss		5.31%	5.31%	5.31%	5.3%	5.3%	5.3%	5.3%	5.3%	5.3%
4. Electricity supply before tranmission										
Electricity supply	Mtoe	76	65	46	65	46	93	75	93	75
Pumped storage (PS)										
Ele. demand of PS	Mtoe	1	1.08	1	1	1	2	1	2	1
Efficiency		84.7%	84.7%	84.7%	84.7%	84.7%	84.7%	84.7%	84.7%	84.7%
Generation of PS	Mtoe	1	1	1	1	1	1	1	1	1
Own use										
Own use in plant	Mtoe	3	3	2	3	2	4	3	4	3
Own use rate										
COL		6.0%	6.0%	6.0%	6.0%	6.0%	6.0%	6.0%	6.0%	6.0%
OIL		5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%
GAS		4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%
NUC		4.4%	4.4%	4.4%	4.4%	4.4%	4.4%	4.4%	4.4%	4.4%
HYD		0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%
HYD(P)		0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%
GEO		8.0%	8.0%	8.0%	8.0%	8.0%	8.0%	8.0%	8.0%	8.0%
BMS		5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%
S/W		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
5. Electricity supply at generation end										
Electricity supply										
Total	Mtoe	81	69	49	70	49	98	79	99	79
COL	Mtoe	15	9	2	13	9	12	4	18	15
OIL	Mtoe	9	3	2	7	5	5	4	11	8
GAS	Mtoe	21	20	18	18	13	29	30	26	21
NUC	Mtoe	28	28	12	24	17	39	20	34	27
HYD	Mtoe	7	8	8	6	4	11	13	8	7
HYD(P)	Mtoe	1	0.92	1	1	1	1	1	1	1
GEO	Mtoe	0	0	0	0	0	0	0	0	0
BMS	Mtoe	0	0	5	0	0	0	8	0	0
S/W	Mtoe	0	0	0	0	0	0	0	0	0
Share of electricity supply										
Total		100%	100%	100%	100%	100%	100%	100%	100%	100%
COL		18%	12%	5%	18%	18%	12%	5%	18%	18%
GAS		11%	5%	5%	11%	11%	5%	5%	11%	11%
OIL		26%	29%	38%	26%	26%	29%	38%	26%	26%
NUC		34%	40%	25%	34%	34%	40%	25%	34%	34%
HYD		8%	11%	16%	8%	8%	11%	16%	8%	8%
HYD(P)		1%	1%	1%	1%	1%	1%	1%	1%	1%
GEO		0%	0%	1%	0%	0%	0%	1%	0%	0%
BMS		0%	0%	10%	0%	0%	0%	10%	0%	0%
S/W		0%	0%	0%	0%	0%	0%	0%	0%	0%
6. Thermal Efficiency										
COL		40.1%	48.0%	48.0%	40.1%	40.1%	48.0%	48.0%	40.1%	40.1%
OIL		37.0%	40.0%	40.0%	37.0%	37.0%	40.0%	40.0%	37.0%	37.0%
GAS		42.2%	55.0%	55.0%	42.2%	42.2%	55.0%	55.0%	42.2%	42.2%
BMS		33.0%	40.0%	40.0%	33.0%	33.0%	40.0%	40.0%	33.0%	33.0%
7. Primary Energy Consumption										
COL	Mtoe	37	18	5	32	23	26	8	45	36
OIL	Mtoe	23	9	6	20	14	12	9	28	23
GAS	Mtoe	51	37	33	43	31	52	54	62	50
NUC	Mtoe	84	84	37	72	51	119	60	102	82
HYD	Mtoe	7	8	8	6	4	11	13	8	6
GEO	Mtoe	3	3	3	2	2	4	5	3	3
BMS	Mtoe	92	69	31	72	51	98	49	102	82
S/W	Mtoe	0	0	5	0	0	0	8	0	0

Conversion factor from secondary to primary : NUC = 1/33%, HYD = 1, GEO = 1/10%, S/W = 1

Fig. 2.7 PWS worksheet

4. Electricity supply before transmission

4-1. Electricity supply

Electricity supply at before transmission. The values are calculated based on the following formulation.

Electricity supply before transmission

= Electricity supply at generation end (5-1)

– Electricity demand of pumped storage(4-2-1) – Own use in plant(4-3-1)

4-2. Pumped storage

4-2-1. Electricity demand of PS

Electricity demand of pumped storage. The values are calculated based on the following formulation.

Electricity demand of pumped storage

= Electricity generation of pumped storage(4-2-3) / Efficiency(4-2-)

4-2-2. Efficiency

Generation efficiency of pumped storage. Enter the value in the base year and the target year.

4-2-3. Generation of PS

Electricity generation of pumped storage. The values are shown based on the following formulation.

Electricity generation of pumped storage

= Electricity supply of pumped storage at generation end(5-1) / (1-Own use rate (4-3))

4-3. Own use

4-3-1. Own use in plant

Electricity consumption for own use in plant. The values are calculated based on the following formulation.

*Own use in plant = Electricity supply(5-1) * Own use rate(4-3-2)*

4-3-2. Own use rate

Electricity consumption for own use in plant. The values are shown based on the following formulation. Enter the value in the base year and the target year.

5. Electricity supply at generation end

5-1. Electricity supply

Electricity supply (=generation) at generation end. The solver calculates the total values. Enter the value of each generation type in a base year. The values of a target year are calculated based on the following formulation.

*Electricity supply = Electricity supply (Total) * Share of electricity supply (5-2)*

5-2. Share of electricity supply

Share of electricity supply by energy input. Enter the value of each generation type in a target year. The values of a base year are calculated based on the following formulation.

Share of electricity supply
= Electricity supply by energy input(5-1) / Total electricity supply

6. Thermal efficiency

Ratio of electricity generation to energy input. Enter the value in a target year. The values of a base year are calculated based on the following formulation.

Thermal efficiency = Electricity generation (5-1) / Energy consumption (7)

7. Primary energy consumption

Primary energy consumption for ratio of electricity generation to energy input. Enter the values in a base year. The values of a target year are calculated based on the following formulation.

Primary energy consumption = Electricity generation (5) / Thermal efficiency (6)

2.4 EB_SD, EB_D, EB_S, EB_0

Energy balance table is developed in “EB_SD”, “EB_D”, “EB_S”, “EB_0”.

- EB_SD: Energy balances considering countermeasures in both enduse sector and energy transformation sector.
- EB_D: Energy balances Considering countermeasures in only enduse sector.
- EB_S: Energy balances Considering countermeasures in only energy transformation sector.
- EB_0 : Energy balances Considering no countermeasures.

“EB_D”, “EB_S”, “EB_0” table is for factor analysis of CO2 reduction.

The explanation of each table is shown as follows.

1. CO_2 emission in 1990

[Line 7, Column F-P]

Enter CO_2 emission in 1990. The value is used for calculation of the emission ratio to the 1990's emission.

2. Energy balances

・Power Gnr.

[Line 12, Column F-P]: Base year

[Line 33, Column F-P]: Scenario 1, Target year

[Line 54, Column F-P]: Scenario 2, Target year

Energy flow of power generation in a base year. Energy consumptions and electricity generation in power generation is shown automatically. The values are linked with energy consumption and electricity generation in PWR.

・CCS, Heat, Coal/Oil/Gas, Hydrogen

[Line 13-16, Column F-P]: Base year

[Line 34-37, Column F-P]: Scenario 1, Target year

[Line 55-58, Column F-P]: Scenario 2, Target year

Energy flow of carbon capture storage, heat plant, production of coal products, oil refinery, gas works and production of hydrogen in a base year.

Enter energy flow in each sector. Energy input is entered with (+), energy output is entered with (-).

・Industrial, Residential, Commercial, Trans. Prs., Trans. Frg.

[Line 17-22, Column F-P]: Base year

[Line 38-43, Column F-P]: Scenario 1, Target year

[Line 59-64, Column F-P]: Scenario 2, Target year

Energy flow of industrial, residential, commercial, passenger transportation and freight transportation sectors in a base year. Energy consumptions and electricity generation in power generation is shown automatically. The values are linked with energy consumption in IND, RES, COM, TR-P and TR-F.

・Total

[Line 23, Column F-P]: Base year

[Line 44, Column F-P]: Scenario 1, Target year

[Line 65, Column F-P]: Scenario 2, Target year

Primary energy consumption. The value is summation of energy input and output of all the sectors.

・Feedstocks in total

[Line 24, Column F-P]: Base year

[Line 45, Column F-P]: Scenario 1, Target year

[Line 66, Column F-P]: Scenario 2, Target year

Feedstocks in total energy consumption. Feedstocks cover energy consumption for products for non-energy use. CO_2 emission is calculated from energy consumption not including feedstocks. Enter feedstocks by energy input.

3. Emission factor

[Line 25]: Base year

[Line 46]: Scenario 1, Target year

[Line 67]: Scenario 2, Target year

CO_2 emission factors are shown automatically. Emission factors of COL, OIL, GAS, BMS, NUC, HYD, S/W is linked with the value in the "CTL" sheet. Emission factors of Heat, H2 and ELE are calculated by the following formulation.

$$EF("Heat") = \sum_{e} EC("Heat", e) * EF(e) / Heat$$

$$EF("H2") = \sum_{e} EC("H2", e) * EF(e) / H2$$

$$EF("ELE") = \left[\sum_{e} \{EC("ELE", e) + EC("CCS", e)\} * EF(e) - CCS \right] / ELE$$

EC: Energy consumption

EF: CO_2 emission factor

Heat: Heat production, *H2*: Hydrogen production, *ELE*: Electricity generation

CCS: Quantity of CO_2 capture and storage

e: Energy (COL, OIL, GAS, BMS, NUC, HYD, S/W)

4. CO_2 Gnr.

[Line 26]: Base year

[Line 47]: Scenario 1, Target year

[Line 68]: Scenario 2, Target year

CO_2 generations are shown automatically. The values are calculated by the following formulation.

*CO_2 generation = (Total energy consumption – Feedstocks) * CO_2 emission factor*

5. CO_2 CCS

[Line 27]: Base year

[Line 48]: Scenario 1, Target year

[Line 69]: Scenario 2, Target year

Enter quantity of CO_2 capture and storage.

6.CO_2 Ems.

[Line 28]: Base year

[Line 49]: Scenario 1, Target year

[Line 70]: Scenario 2, Target year

CO_2 emissions are shown automatically. The values are calculated by the following formulation.

$$CO_2\ emission = CO_2\ generation - CO_2\ CCS$$

Energy Balances / CO2 Emission

1990

	COL	OIL	GAS	BMS	NUC	HYD	S/W	Heat	H2	ELE	Total	'90=100
CO2 Ems. (MtC)											284	100

2000

	COL	OIL	GAS	BMS	NUC	HYD	S/W	Heat	H2	ELE	Total	'90=100	COL	OIL	GAS	BMS	NUC	HYD	S/W	Heat	H2	ELE	Total
Energy Balances (Mtoe)													CO2 Emission (MtC)										
Power Gnr.	37	23	51	92	84	7	3			-72	224												
CCS											0												
Heat											0												
Coal/Oil/Gas		11									11		0	9	0	0	0	0	0	0	0	0	9
Hydrogen											0												
Industrial	46	99	10	7			0	0	0	28	190		48	54	5	0	0	0	0	0	0	33	141
Residential	0	21	9	0			1	0	0	23	54		0	16	5	0	0	0	0	0	0	27	49
Commercial	0	15	9	0			1	0	0	22	46		0	12	5	0	0	0	0	0	0	26	43
Trans. Prv.	0	54	0	0			0	0	0	2	56		0	43	0	0	0	0	0	0	0	2	45
Trans. Frg.	0	34	0	0			0	0	0	0	34		0	27	0	0	0	0	0	0	0	0	28
Enduse	46	223	28	7			1	0	0	75	380		48	153	15	0	0	0	0	0	0	89	306
Total	83	257	79	100	84	7	4	0	0	3	616		48	162	15	0	0	0	0	0	0	89	315
Feedstock in total		31																					
Emission Factor (MtC/Mtoe)	1.05	0.80	0.55	0.00	0.00	0.00	0.00	-	-	-			1.05	0.80	0.55	0.00	0.00	0.00	0.00	0.00	0.00	1.19	-
CO2 Gnr. (MtC)	87	181	43	0	0	0	0	-	-	-	311	110											
CO2 CCS (MtC)								-	-	-													
CO2 Ems. (MtC)	87	180.8	43	0	0	0	0	-	-	-	311	110											

2050 A (CM)

	COL	OIL	GAS	BMS	NUC	HYD	S/W	Heat	H2	ELE	Total	'90=100	COL	OIL	GAS	BMS	NUC	HYD	S/W	Heat	H2	ELE	Total
Energy Balances																							
Power Gnr.	18	9	37	69	84	8	3			-62	166												
CCS			2								2												
Heat											0												
Coal/Oil/Gas		3									3		0	2	0	0	0	0	0	0	0	0	2
Hydrogen			18				13		-19		12												
Industrial	15	48	34	3			0	0	1	26	127		15	26	19	0	0	0	0	0	0	7	68
Residential	0	1	1	0			8	0	4	14	28		0	1	0	0	0	0	0	0	2	4	7
Commercial	0	1	1	0			3	0	3	19	26		0	0	0	0	0	0	0	0	1	5	8
Trans. Prv.	0	4	0	3			0	0	5	2	14		0	3	0	0	0	0	0	0	3	1	6
Trans. Frg.	0	2	0	1			0	0	6	1	10		0	1	0	0	0	0	0	0	3	0	5
Enduse	15	56	36	7			11	0	19	62	205		15	32	20	0	0	0	0	0	10	17	95
Total	33	67	93	76	84	8	27	0	0	0	388		15	35	20	0	0	0	0	0	10	17	97
Feedstock in total		15																					
Emission Factor (MtC/Mtoe)	1.05	0.80	0.55	0.00	0.00	0.00	0.00	-	-	-			1.05	0.80	0.55	0.00	0.00	0.00	0.00	0.00	0.52	0.28	-
CO2 Gnr. (MtC)	34	42	51	0	0	0	0	-	-	-	127	45											
CO2 CCS (MtC)			-30					-	-	-													
CO2 Ems. (MtC)	34	41.6	21	0	0	0	0	-	-	-	97	34											

2050 B (CM)

	COL	OIL	GAS	BMS	NUC	HYD	S/W	Heat	H2	ELE	Total	'90=100	COL	OIL	GAS	BMS	NUC	HYD	S/W	Heat	H2	ELE	Total
Energy Balances																							
Power Gnr.	5	6	33	31	37	8	8			-44	83												
CCS											0												
Heat											0												
Coal/Oil/Gas		2									2		0	2	0	0	0	0	0	0	0	0	2
Hydrogen											0												
Industrial	14	40	26	16			0	0	0	21	117		15	20	14	0	0	0	0	0	0	13	62
Residential	0	2	2	7			18	0	0	8	37		0	1	1	0	0	0	0	0	0	5	7
Commercial	0	1	2	6			7	0	0	15	31		0	1	1	0	0	0	0	0	0	9	12
Trans. Prv.	0	2	0	14			0	0	0	1	16		0	1	0	0	0	0	0	0	0	0	2
Trans. Frg.	0	1	0	17			0	0	0	0	18		0	1	0	0	0	0	0	0	0	0	1
Enduse	14	46	30	60			25	0	0	44	220		15	24	16	0	0	0	0	0	0	28	83
Total	19	54	63	91	37	8	33	0	0	0	305		15	26	16	0	0	0	0	0	0	28	85
Feedstock in total		15																					
Emission Factor (MtC/Mtoe)	1.05	0.80	0.55	0.00	0.00	0.00	0.00	-	-	-			1.05	0.80	0.55	0.00	0.00	0.00	0.00	0.00	0.00	0.63	-
CO2 Gnr. (MtC)	20	31	35	0	0	0	0	-	-	-	85	30											
CO2 CCS (MtC)								-	-	-													
CO2 Ems. (MtC)	20	30.5	35	0	0	0	0	-	-	-	85	30											

Fig. 2.8 EB worksheet

2.5 Factors

The “Factors” worksheet shows factors analysis of CO_2 emission. CO_2 emission is divided into four factors as follows.

$$C = D \times \frac{E}{D} \times \frac{C'}{E} \times \frac{C}{C'}$$

C: CO_2 emission, D: Driving force, E: Energy consumption

C’: CO_2 emission without countermeasure in energy transformation sector

Change of CO_2 emission is formulated as follows.

$$C + \Delta C = (D + \Delta D) \times (\frac{E}{D} + \Delta \frac{E}{D}) \times (\frac{C'}{E} + \Delta \frac{C'}{E}) \times (\frac{C}{C'} + \Delta \frac{C}{C'})$$

E/D: Energy intensity

C’/E: CO_2 intensity without countermeasure in energy transformation sector

C/C’: Change of CO_2 intensity by countermeasure in energy transformation sector

$$\frac{\Delta C}{C} = [\text{Contribution of } D\text{'s change}] + [\text{Contribution of } (E/D)\text{'s change}] + [\text{Contribution of } (C'/E)\text{'s change}] + [\text{Contribution of } (C/C')\text{'s change}]$$

$$[\text{Contribution of } D\text{'s change}] = \frac{\Delta D}{D} + \frac{1}{2} \times \left(\frac{\Delta D}{D} \times \frac{\Delta(E/D)}{(E/D)} + \frac{\Delta D}{D} \times \frac{\Delta(C'/E)}{(C'/E)} + \frac{\Delta D}{D} \times \frac{\Delta(C/C')}{(C/C')} \right) + \frac{1}{3} \times \left(\frac{\Delta D}{D} \times \frac{\Delta(E/D)}{(E/D)} \times \frac{\Delta(C'/E)}{(C'/E)} + \frac{\Delta D}{D} \times \frac{\Delta(E/D)}{(E/D)} \times \frac{\Delta(C/C')}{(C/C')} + \frac{\Delta D}{D} \times \frac{\Delta(C'/E)}{(C'/E)} \times \frac{\Delta(C/C')}{(C/C')} \right) + \frac{1}{4} \times \left(\frac{\Delta D}{D} \times \frac{\Delta(E/D)}{(E/D)} \times \frac{\Delta(C'/E)}{(C'/E)} \times \frac{\Delta(C/C')}{(C/C')} \right)$$

$$[\text{Contribution of } (E/D)\text{'s change}] = \frac{\Delta(E/D)}{(E/D)} + \frac{1}{2} \times \left(\frac{\Delta D}{D} \times \frac{\Delta(E/D)}{(E/D)} + \frac{\Delta(E/D)}{(E/D)} \times \frac{\Delta(C'/E)}{(C'/E)} + \frac{\Delta(E/D)}{(E/D)} \times \frac{\Delta(C/C')}{(C/C')} \right) + \frac{1}{3} \times \left(\frac{\Delta D}{D} \times \frac{\Delta(E/D)}{(E/D)} \times \frac{\Delta(C'/E)}{(C'/E)} + \frac{\Delta D}{D} \times \frac{\Delta(E/D)}{(E/D)} \times \frac{\Delta(C/C')}{(C/C')} + \frac{\Delta(E/D)}{(E/D)} \times \frac{\Delta(C'/E)}{(C'/E)} \times \frac{\Delta(C/C')}{(C/C')} \right) + \frac{1}{4} \times \left(\frac{\Delta D}{D} \times \frac{\Delta(E/D)}{(E/D)} \times \frac{\Delta(C'/E)}{(C'/E)} \times \frac{\Delta(C/C')}{(C/C')} \right)$$

$$[\text{Contribution of } (C'/E)\text{'s change}] = \frac{\Delta(C'/E)}{(C'/E)} + \frac{1}{2} \times \left(\frac{\Delta D}{D} \times \frac{\Delta(C'/E)}{(C'/E)} + \frac{\Delta(E/D)}{(E/D)} \times \frac{\Delta(C'/E)}{(C'/E)} + \frac{\Delta(C'/E)}{(C'/E)} \times \frac{\Delta(C/C')}{(C/C')} \right) + \frac{1}{3} \times \left(\frac{\Delta D}{D} \times \frac{\Delta(E/D)}{(E/D)} \times \frac{\Delta(C'/E)}{(C'/E)} + \frac{\Delta D}{D} \times \frac{\Delta(C'/E)}{(C'/E)} \times \frac{\Delta(C/C')}{(C/C')} + \frac{\Delta(E/D)}{(E/D)} \times \frac{\Delta(C'/E)}{(C'/E)} \times \frac{\Delta(C/C')}{(C/C')} \right) + \frac{1}{4} \times \left(\frac{\Delta D}{D} \times \frac{\Delta(E/D)}{(E/D)} \times \frac{\Delta(C'/E)}{(C'/E)} \times \frac{\Delta(C/C')}{(C/C')} \right)$$

$$[\text{Contribution of } (C/C')\text{'s change}] = \frac{\Delta(C/C')}{(C/C')} + \frac{1}{2}\times\left(\frac{\Delta D}{D}\times\frac{\Delta(C/C')}{(C/C')} + \frac{\Delta(E/D)}{(E/D)}\times\frac{\Delta(C/C')}{(C/C')} + \frac{\Delta(C'/E)}{(C'/E)}\times\frac{\Delta(C/C')}{(C/C')}\right)$$
$$+\frac{1}{3}\times\left(\frac{\Delta D}{D}\times\frac{\Delta(E/D)}{(E/D)}\times\frac{\Delta(C/C')}{(C/C')} + \frac{\Delta D}{D}\times\frac{\Delta(C'/E)}{(C'/E)}\times\frac{\Delta(C/C')}{(C/C')} + \frac{\Delta(E/D)}{(E/D)}\times\frac{\Delta(C'/E)}{(C'/E)}\times\frac{\Delta(C/C')}{(C/C')}\right)$$
$$+\frac{1}{4}\times\left(\frac{\Delta D}{D}\times\frac{\Delta(E/D)}{(E/D)}\times\frac{\Delta(C'/E)}{(C'/E)}\times\frac{\Delta(C/C')}{(C/C')}\right)$$

The explanation of the table in “Factors” is shown as follows.

[Line 6] Reduction rate of CO_2 emission by change of driving force

[Line 7] Reduction rate of CO_2 emission by change of energy intensity

[Line 8] Reduction rate of CO_2 emission by change of CO_2 intensity without countermeasures in energy transformation sector.

[Line 9] Change of CO_2 intensity by countermeasure in energy transformation sector

[Line 10] Change of CO_2 emission in each sector compared to a base year.

[Line 11] CO2 emission share in a base year.

		2050 A						2050 B					
		IND	RES	COM	TR-P	TR-F	Total	IND	RES	COM	TR-P	TR-F	Total
Change rate	D	-10%	-4%	7%	-12%	0%	-6%	-19%	-11%	-2%	-10%	-6%	-13%
2050/2000	E/D	-15%	-26%	-36%	-48%	-57%	-28%	-11%	-7%	-20%	-31%	-19%	-15%
	C/E	-5%	-10%	3%	-14%	-14%	-7%	-14%	-46%	-22%	-48%	-70%	-30%
	C'/C	-22%	-45%	-57%	-11%	-10%	-28%	-12%	-22%	-29%	-7%	-2%	-14%
	Total	-52%	-85%	-82%	-86%	-82%	-69%	-56%	-85%	-73%	-96%	-97%	-73%
CO2 share	2000	46%	16%	14%	15%	9%	100%	46%	16%	14%	15%	9%	100%

Fig. 2.9 Factors analysis table in Factors worksheet

2.6 EneEms

Graphs of energy consumption and CO2 emission are shown in the “EneEms” worksheet.

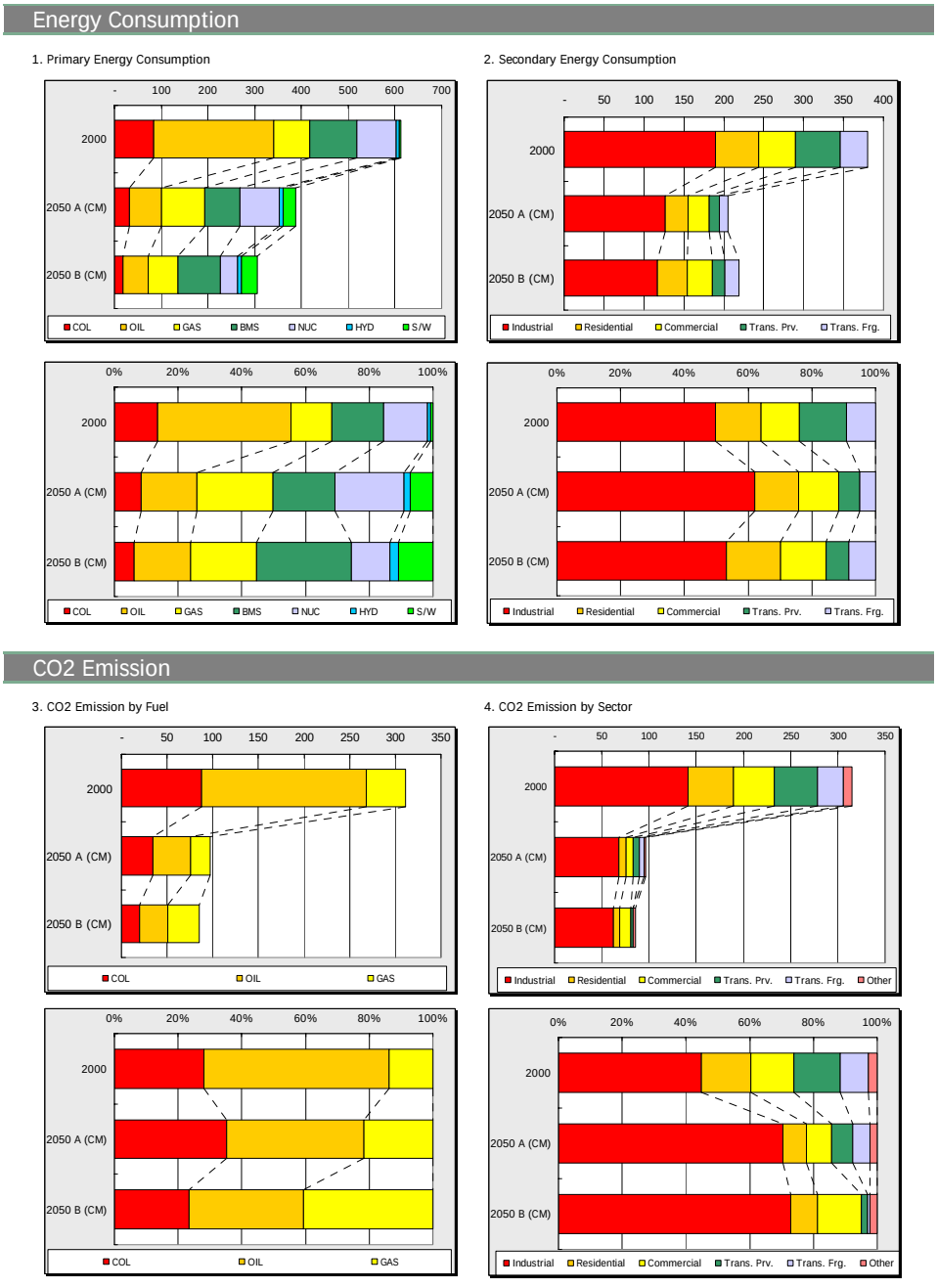

Fig. 2.10 Factors analysis table in Factors worksheet

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