AIM/Energy Snapshot Tool (ESS)

AIM Training Workshop

Tokyo, Japan Oct 22-27, 2007

Contents

- Background
- Structures & Flows
- Operation
  - Demand Settings
  - Transformation Sector (Electricity, Other)
  - Analysis
  - Exercise

Contents

Background

Background of development

- In LCS/SD visions developing processes, a tool with following feature would be useful
  - Clear assumptions & calculation processes
  - Easy interpretation of the results
  - Easy sensitivity analysis (assumptions can be changed manually)
  - Quick calculation
  - Overview of general energy flow (keep balance)

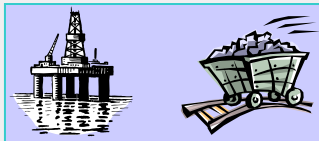
- Tools to describe future (ex. 2050) Energy Balance Table (EBT) in a spreadsheet: **Energy Snapshot Tool （ESS）**

AIM/Energy snapshot tool

- Excel format
- Based on EBT
- Step by step approach
- The tool can be used for;
  - Developing and designing preliminary LCS/SD visions
  - “What if” analysis
  - Check the consistency among the sectors
  - Analyze the impacts of countermeasures package
  - Communication among stakeholders

General Energy Flow

Production



Total Primary Energy Supply

Import/Export

Energy stock

Transformation & Distribution Technologies

Final Energy Consumption

Losses

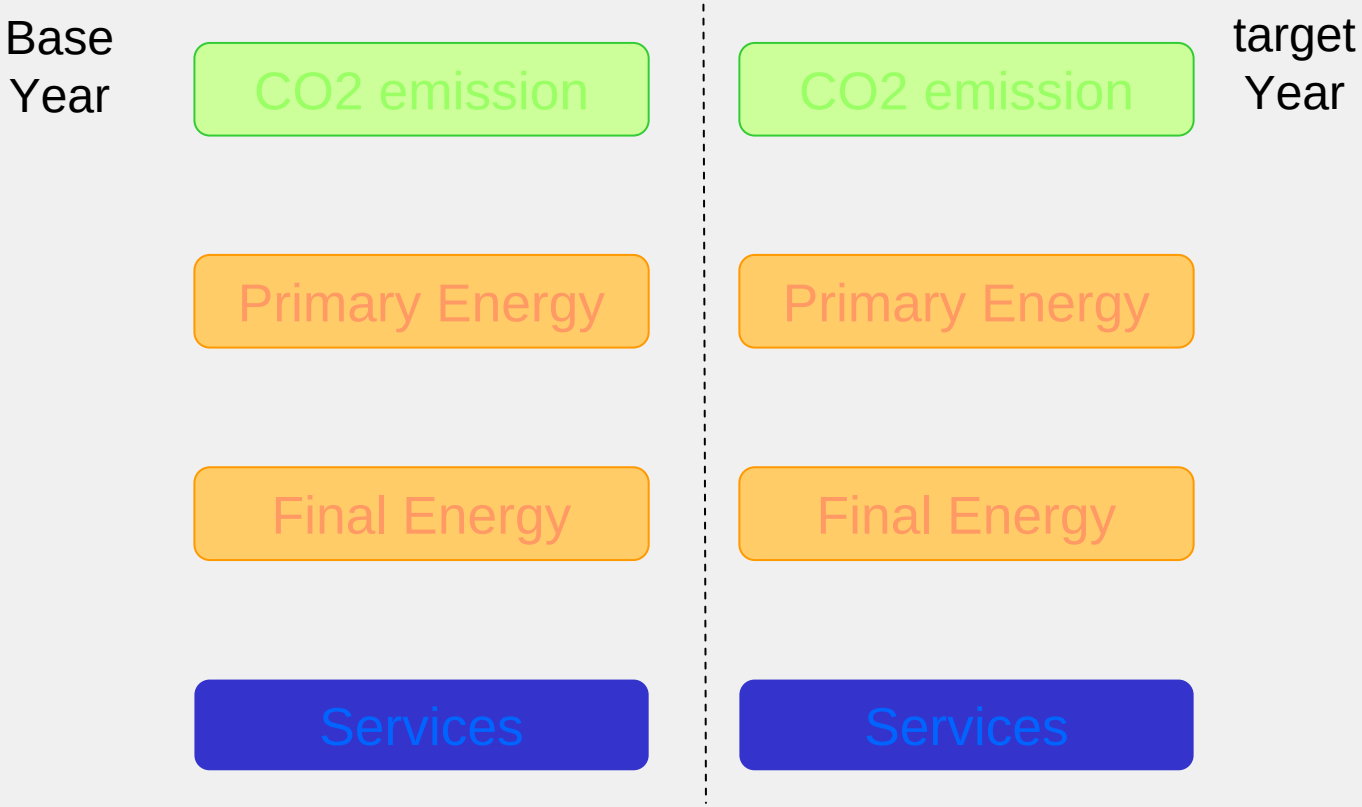
Technology producing the demanded services

Services

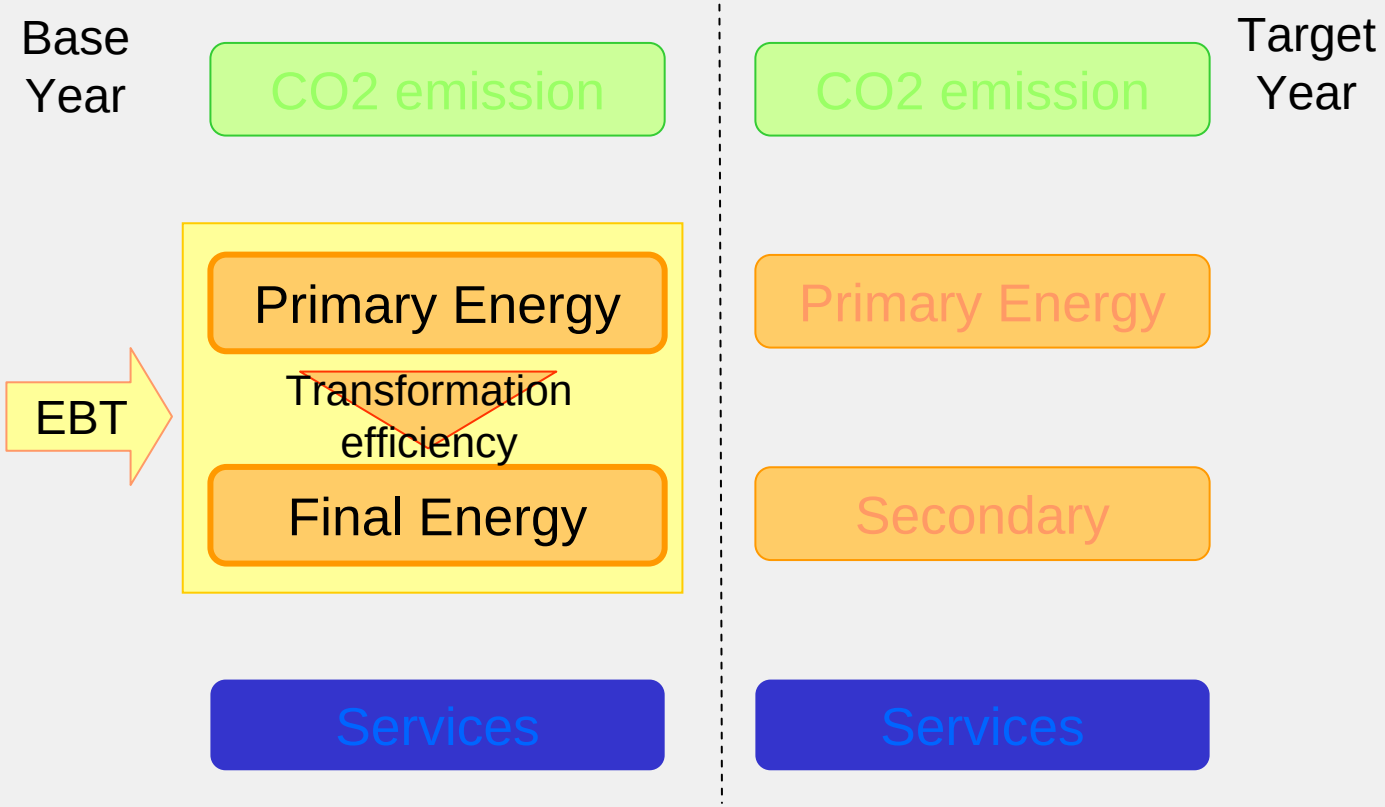
Contents

Structure & Flow

Calculation processes

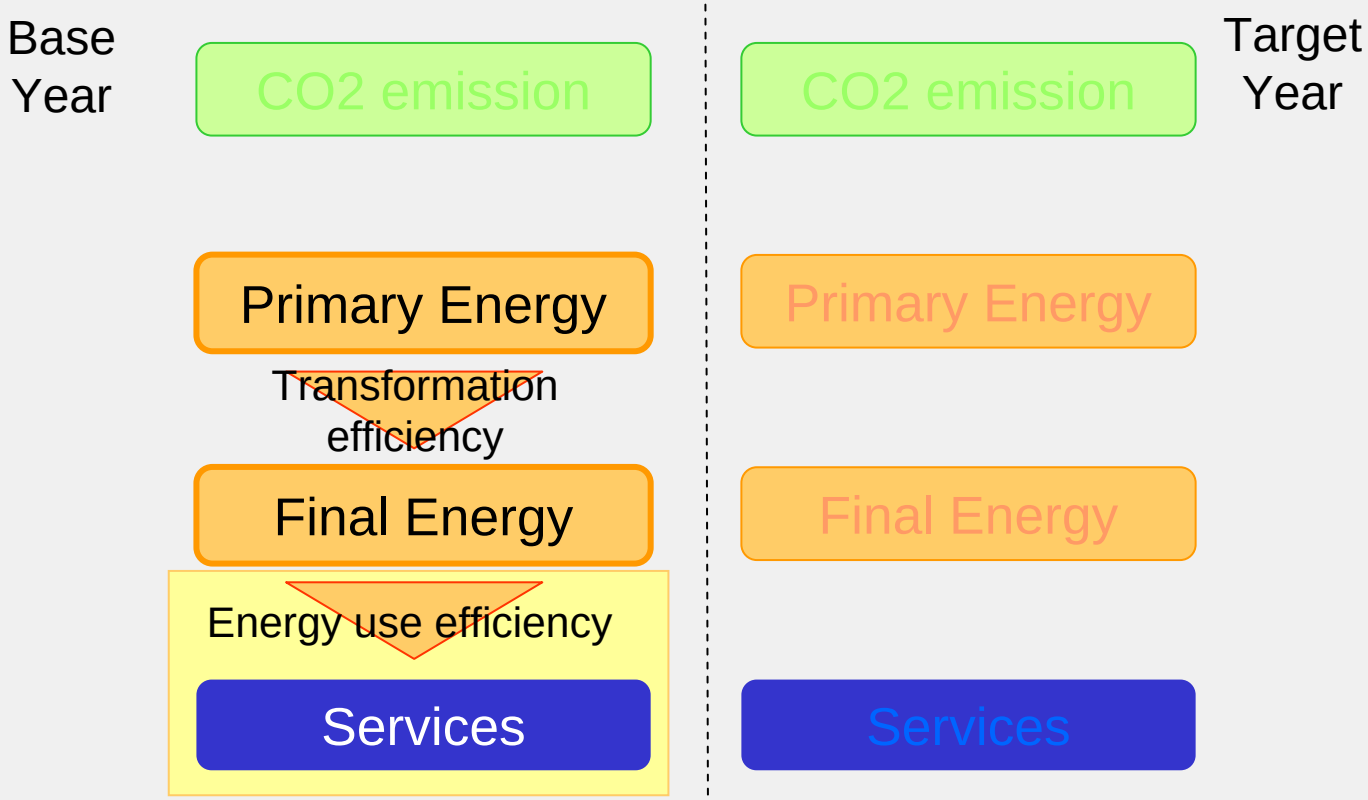


Calculation processes



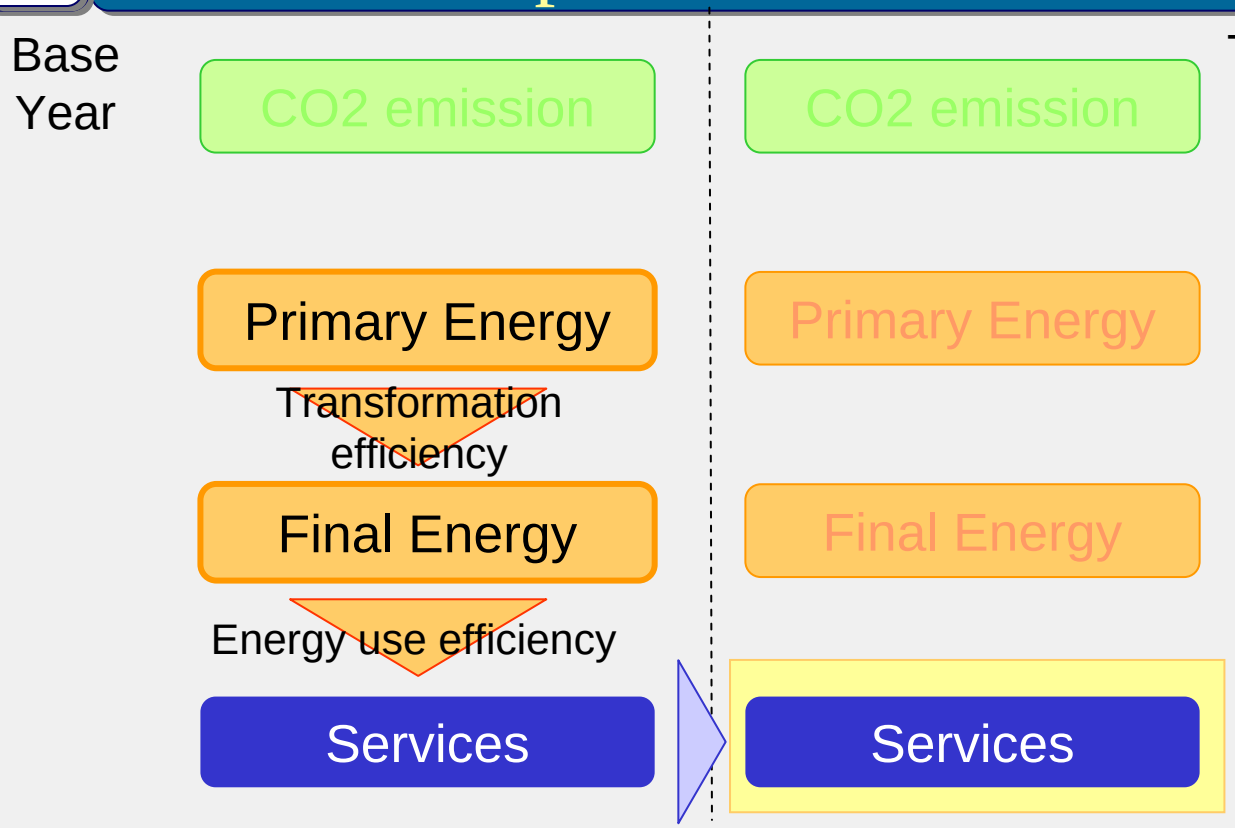
1. Obtain EBT from national statistics etc. (Base Year)

Calculation processes



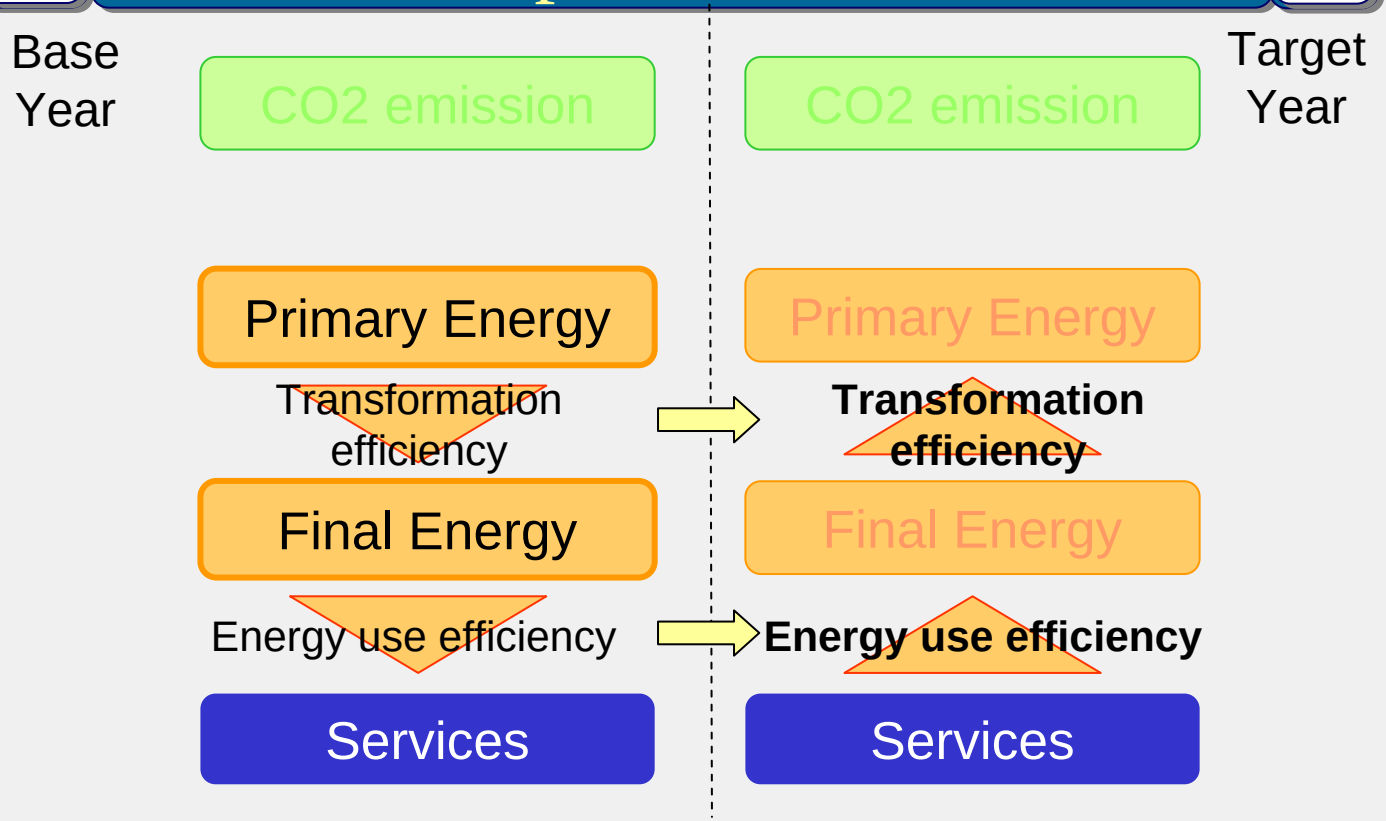
2. Set energy use efficiency & Services demand
   Services/Final Energy (C/S) ratio (Base Year)

Calculation processes



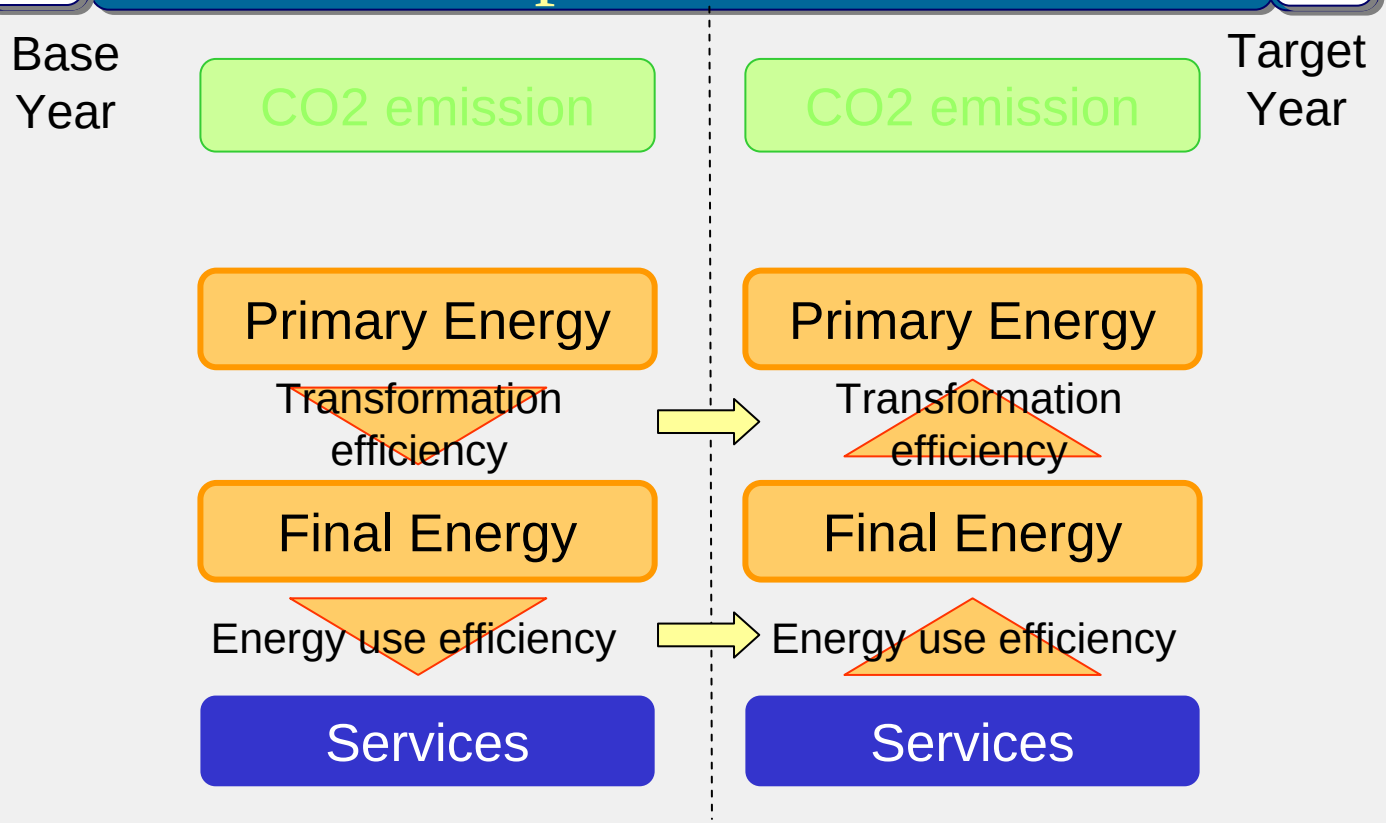
3. Assume changes in “Energy service demand” in Target Year (Scenarios or Visions)

Calculation processes



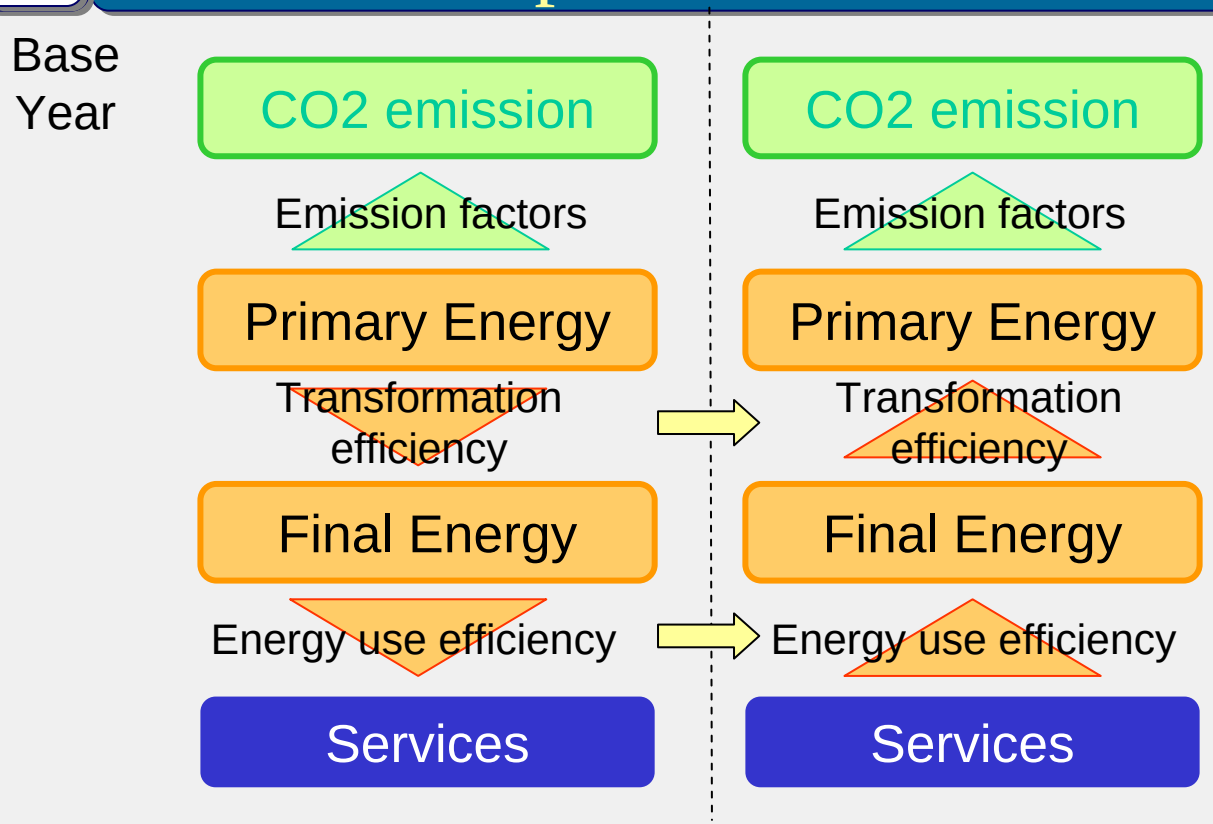
3. Assume changes in parameters in Target Year (Scenarios or Visions)

Calculation processes



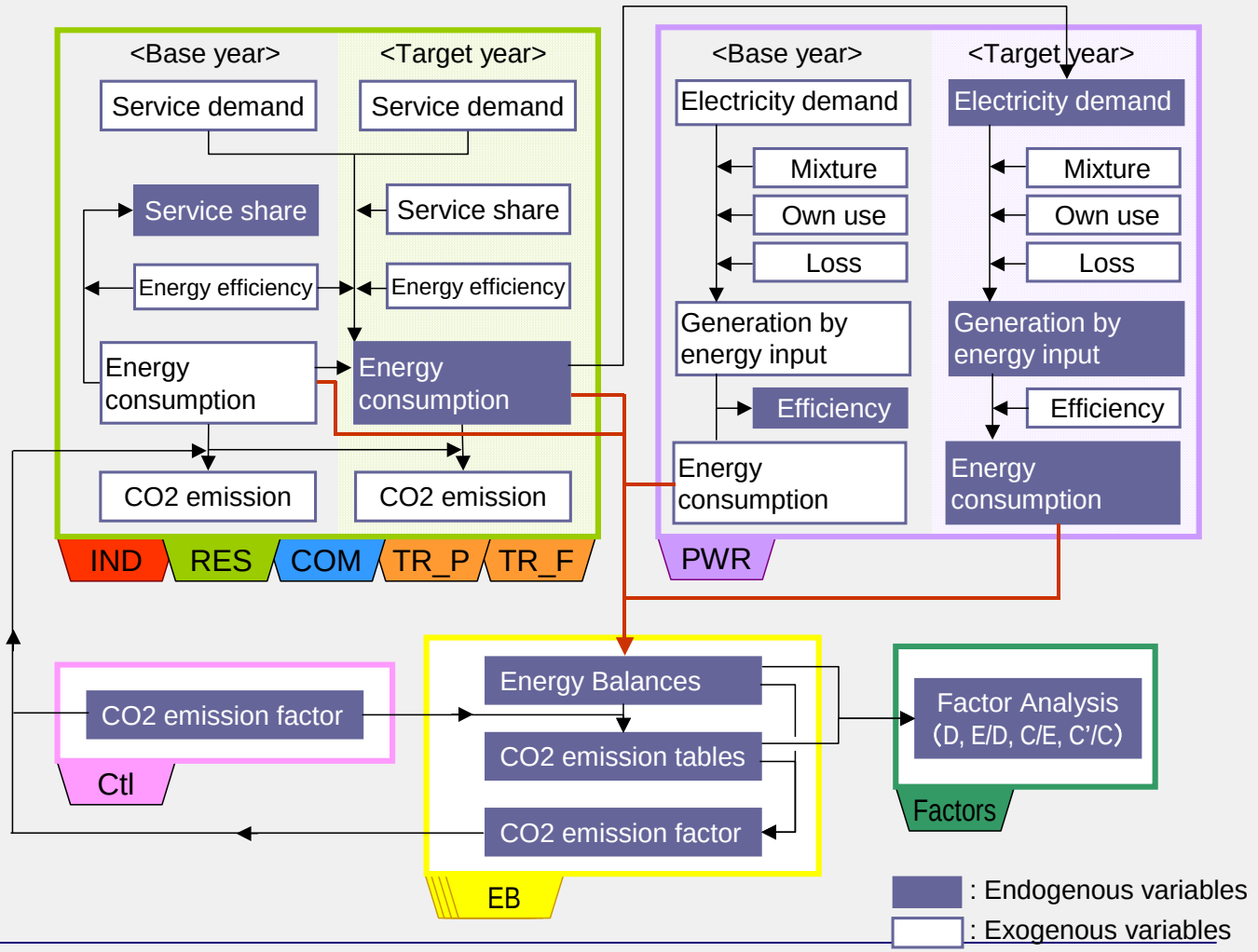
4. Calculate energy Primary Energy and Final Energy in Target Year

Calculation processes



5. Calculate CO2 emissions by multiplying "emission factors" of each energy

Structure of the model



Worksheets

Name	Contents
Title	Cover of ESS
CTL	Unit, simulation year, visions name and CO2 emission factor
RES	Residential sector
IND	Industrial sector
COM	Commercial sector
TR_P	Passenger transportation sector
TR_F	Freight transportation sector

Worksheets

Name	Contents
EB_SD	Energy balance table (Service & Demand side countermeasures)
EB_S	Energy balance table (Service side countermeasures)
EB_D	Energy balance table (Demand side countermeasures)
EB_0	Energy balance table (No counter measures = Reference case)
Factors	Factors analysis of CO_2 reduction
EneEms	Graphs of energy cons. and CO_2 emissions

Contents

Operation

Fundamental settings (CTL)

Unit, Simulation Year, Scenario Name, Emission Factor

Unit

Energy	CO2
Mtoe	MtC

Simulation Year

Base Year	Target Year
2000	2050

Scenario Name

Scenario 1	Scenario 2
A	B

Emission Factor

COL	OIL	GAS	BMS	NUC	HYD	S/W
1.05	0.8	0.55	0	0	0	0

Unit: MtC / Mtoe

General rules

- White cells: User input
- Colored cells: Automatically calculated values

Demand Settings

Residential | Transportation_P | Industry

Commercial | Transportation_F

Residential sector

1 Energy service demand

	Unit	2000	2050					
			REF		CM		CM/REF	
			A	B	A	B	A	B
Cool	Mtoe	4	4	4	4	4	90%	100%
Warm	Mtoe	81	81	81	65	81	80%	100%
Hot Water	Mtoe	55	55	55	55	55	100%	100%
Cooking	Mtoe	60	60	60	30	60	50%	100%
Others	Mtoe	5	5	5	5	5	100%	100%
	Mtoe				0	0		
	Mtoe				0	0		
	Mtoe				0	0		
	Mtoe				0	0		
	Mtoe				0	0		

REF = Reference case
CM = Countermeasure case

4-6 Energy consumption / CO2 Emission

		Unit	COL	OIL	GAS	BMS	S/W
4 Energy Consumption	2000	Mtoe	45	13	5	213	0
	2050 A (CM)		53	12	38	86	0
	2050 B (CM)		45	13	5	214	0
5 Emission Factor	2000	MtC/Mtoe	1.05	0.80	0.55	0.00	0.00
	2050 A (CM)		1.05	0.80	0.55	0.00	0.00
	2050 B (CM)		1.05	0.80	0.55	0.00	0.00
6 CO2 Emission	2000	MtC	47	10	3	0	0
	2050 A (CM)		56	10	21	0	0
	2050 B (CM)		47	10	3	0	0

2 Service Share

	Unit	2000								
		COL	OIL	GAS	BMS	S/W	Heat	H2	ELE	Total
Cool	-	0%	0%	0%	0%	0%	0%	0%	100%	100%
Warm	-	23%	8%	2%	48%	0%	3%	0%	16%	100%
Hot Water	-	14%	4%	1%	71%	0%	5%	0%	4%	100%
Cooking	-	7%	0%	1%	92%	0%	0%	0%	0%	100%
Others	-	0%	0%	0%	0%	0%	0%	0%	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%	0%	0%	0%
	-	0%	0%	0%	0%	0%	0%	0%	0%	0%
	-	0%	0%	0%	0%	0%	0%	0%	0%	0%

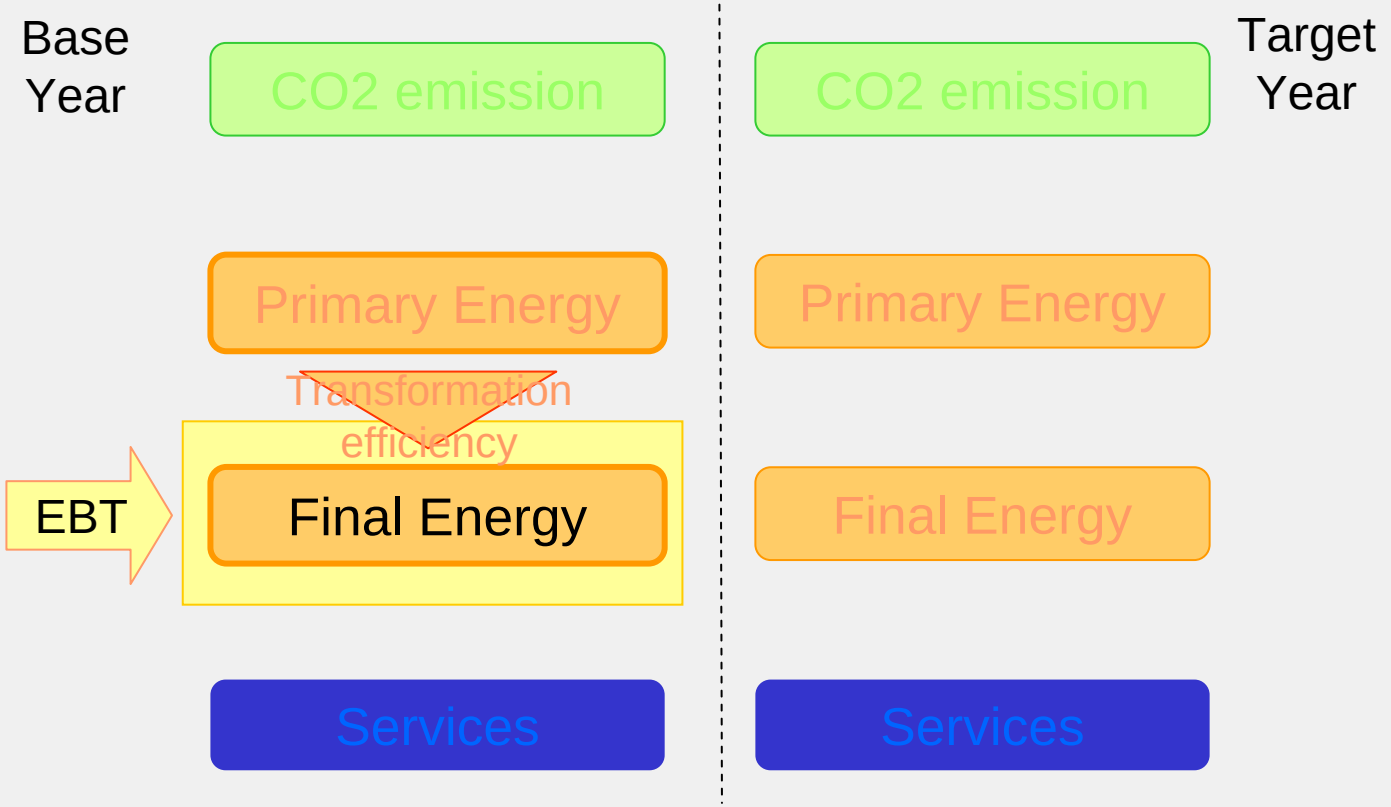
	2050 A (CM)								
	COL	OIL	GAS	BMS	S/W	Heat	H2	ELE	Total
Cool	0%	0%	0%	0%	0%	0%	0%	100%	100%
Warm	61%	8%	2%	10%	0%	3%	0%	16%	100%
Hot Water	0%	6%	50%	30%	0%	10%	0%	4%	100%
Cooking	7%	0%	1%	92%	0%	0%	0%	0%	100%
Others	0%	0%	0%	0%	0%	0%	0%	100%	100%
	0%	0%	0%	0%	0%	0%	0%	0%	0%
	0%	0%	0%	0%	0%	0%	0%	0%	0%
	0%	0%	0%	0%	0%	0%	0%	0%	0%
	0%	0%	0%	0%	0%	0%	0%	0%	0%
	0%	0%	0%	0%	0%	0%	0%	0%	0%

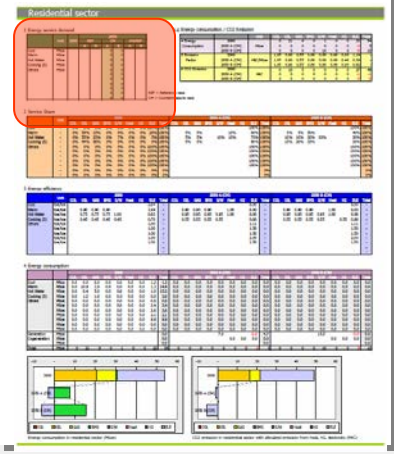
	2050 B (C				
	COL	OIL	GAS	BMS	S/W
Cool	0%	0	0	0%	0%
Warm	23%	8%	2%	48%	0%
Hot Water	14%	4%	1%	71%	0%
Cooking	7%	0%	1%	92%	0%
Others	0%	0%	0%	0%	0%
	0%	0	0	0%	0%
	0%	0	0	0	0
	0%	0	0	0	0
	0%	0	0	0	0
	0%	0	0	0	0

Contents

Demand Setting (Residential Sector)

Calculation processes



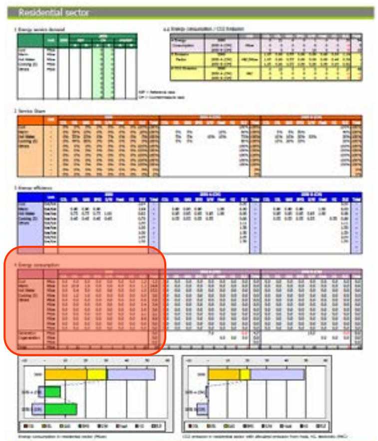


0. Preparation

- Split or merge energy consumption from EBT and set the category

	Unit	2000	2050					
			REF		CM		CM/REF	
			A	B	A	B	A	B
Cool	Mtoe	4	4	4	4	4	90%	100%
Warm	Mtoe	81	81	81	65	81	80%	100%
Hot Water	Mtoe	55	55	55	55	55	100%	100%
Cooking	Mtoe	60	60	60	30	60	50%	100%
Others	Mtoe	5	5	5	5	5	100%	100%
	Mtoe				0	0		
	Mtoe				0	0		
	Mtoe				0	0		
	Mtoe				0	0		
					0	0		
					0	0		

Contents

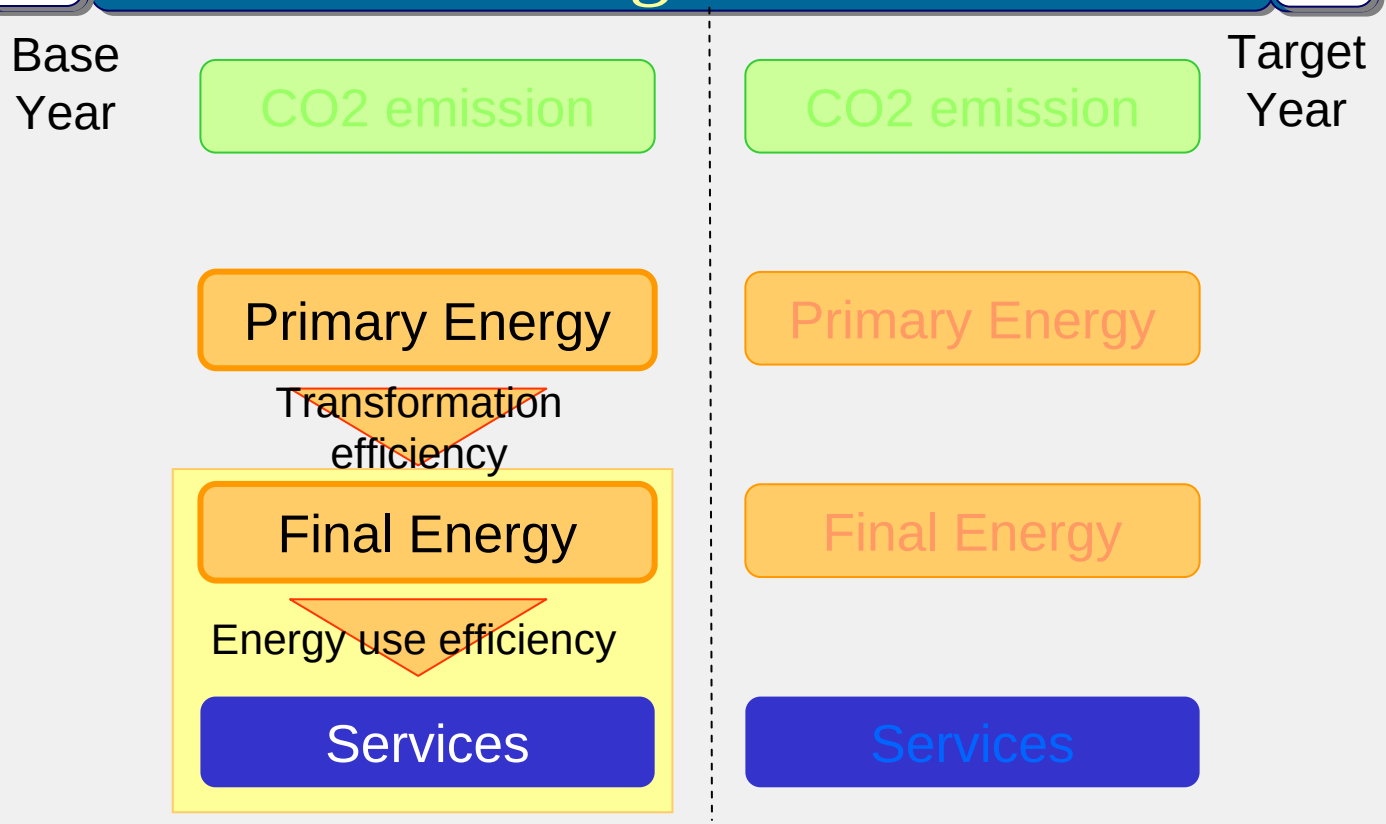


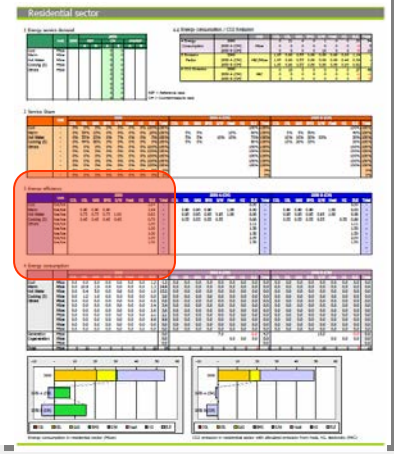
0. Energy Cons. in base year

- Past record of energy use in each sector
- Same structure as EBT
- Allocate energy consumption along with set categories

		2000								
		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	2.0	2.0
Warm	Mtoe	30.0	10.0	3.0	50.0	0.0	3.0	0.0	5.0	101.0
Hot Water	Mtoe	10.0	3.0	1.0	50.0	0.0	3.0	0.0	2.0	69.0
Cooking	Mtoe	5.0	0.0	1.0	113.0	0.0	0.0	0.0	0.0	119.0
Others	Mtoe	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0	5.0
	Mtoe	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
	Mtoe	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
	Mtoe	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
Generation	Mtoe									0.0
Cogeneration	Mtoe									0.0
	Mtoe									0.0
Total	Mtoe	45	13	5	213	0	6	0	14	296

Demand Setting 1



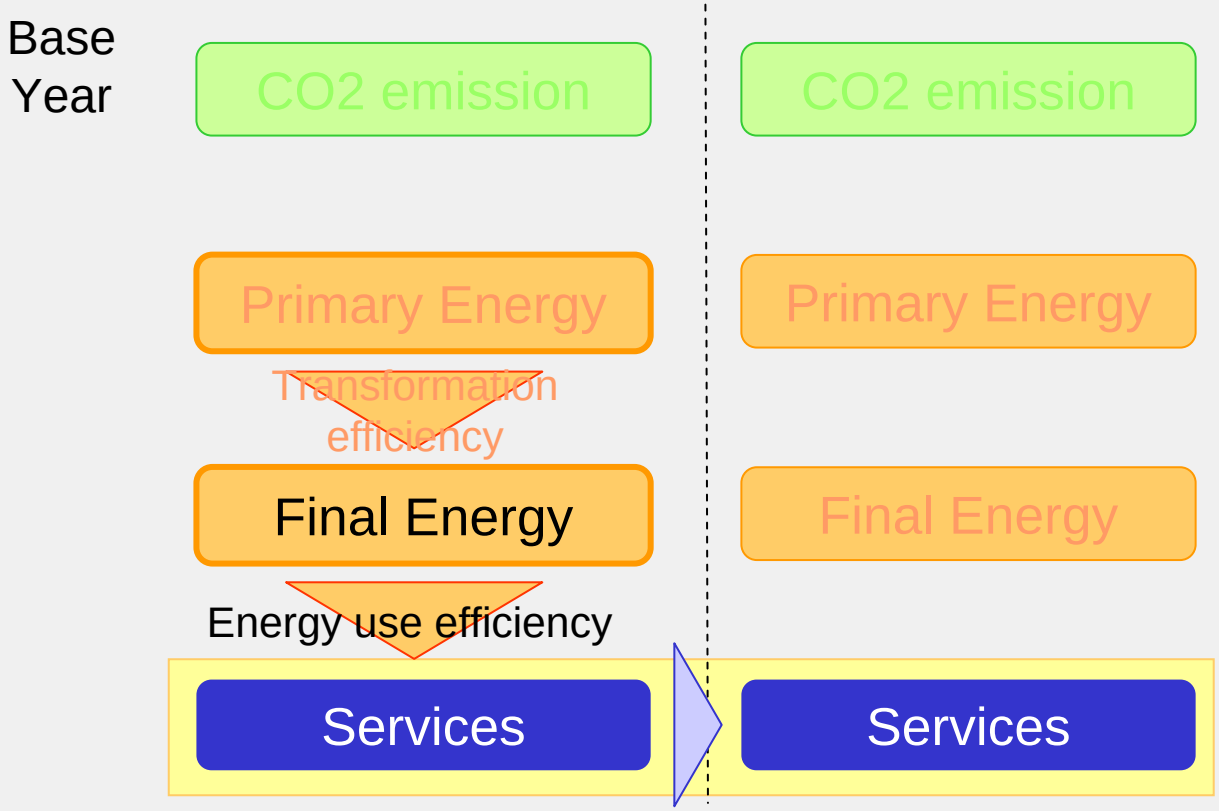


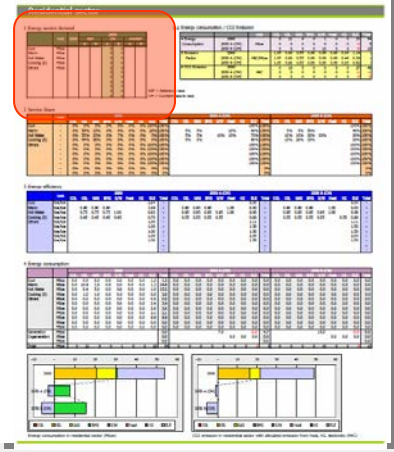
2. Energy use eff. in base year

- Set energy efficiency of each energy use
  - Energy use efficiency: Ratio between the consumption of energy to service demand
  - Keep consistency
  - The value can be relative value (Base Year=1.00)

	Unit	2000								
		COL	OIL	GAS	BMS	S/W	Heat	H2	ELE	Total
Cool	toe/toe								2.00	-
Warm	toe/toe	0.70	0.70	0.70	0.90		1.00		3.00	-
Hot Water	toe/toe	0.80	0.80	0.80	0.80	1.00	1.00		1.00	-
Cooking	toe/toe	0.80		0.50	0.45	0.45			0.70	-
Others	toe/toe								1.00	-
	toe/toe									-
	toe/toe									-
	toe/toe									-
	toe/toe									-
										-
										-

Demand Setting 1



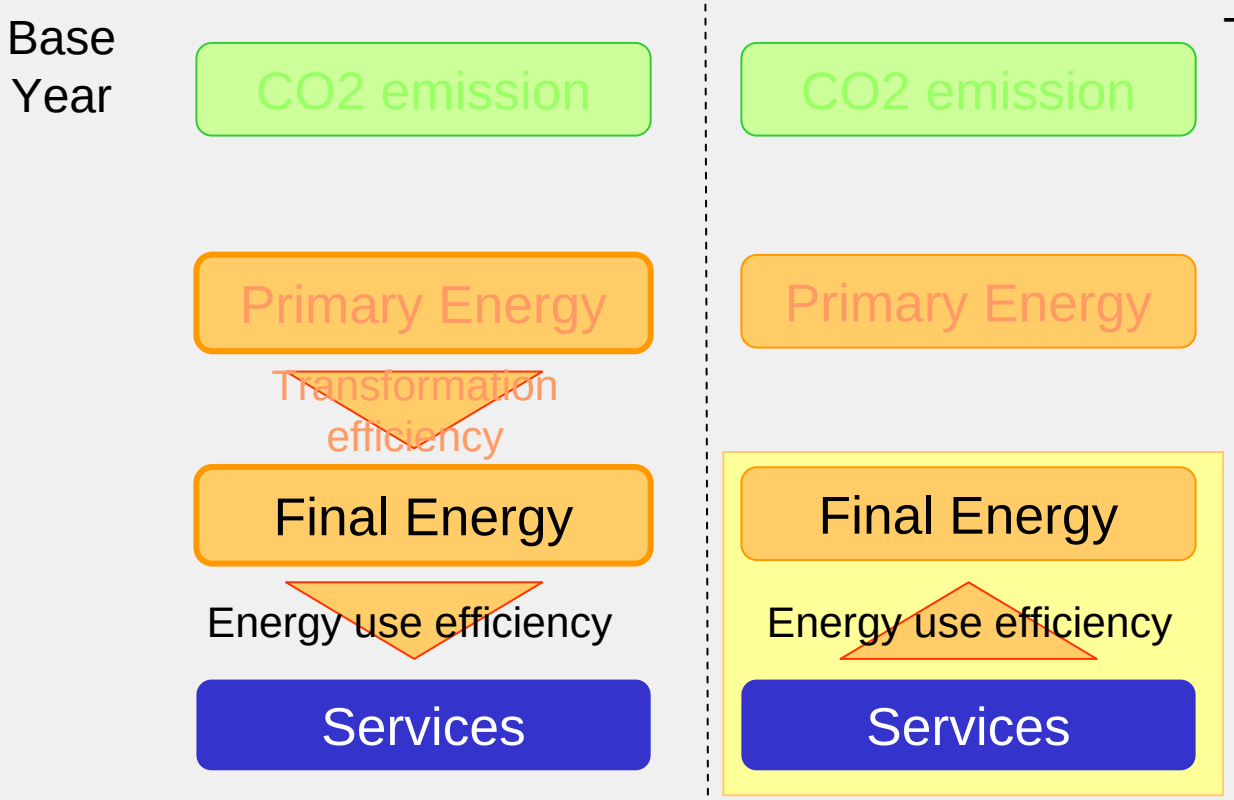


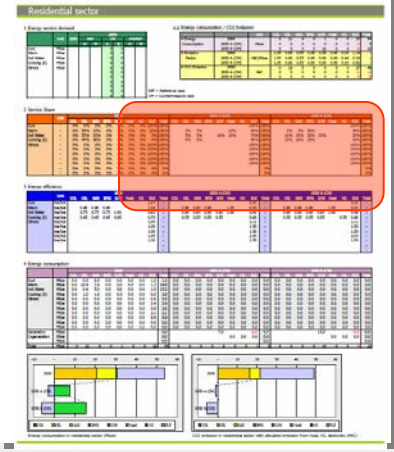
3. Service Demand

- Service demand in base year
  - Service demand (Mtoe) = Final Energy/EE
- Assume service demand in target year
- Reference case, Countermeasure case

	Unit	2000	2050					
			REF		CM		CM/REF	
			A	B	A	B	A	B
Cool	Mtoe	4	4	4	4	4	90%	100%
Warm	Mtoe	81	81	81	65	81	80%	100%
Hot Water	Mtoe	55	55	55	55	55	100%	100%
Cooking	Mtoe	60	60	60	30	60	50%	100%
Others	Mtoe	5	5	5	5	5	100%	100%
	Mtoe				0	0		
	Mtoe				0	0		
	Mtoe				0	0		
	Mtoe				0	0		
					0	0		
					0	0		

Demand Setting 1

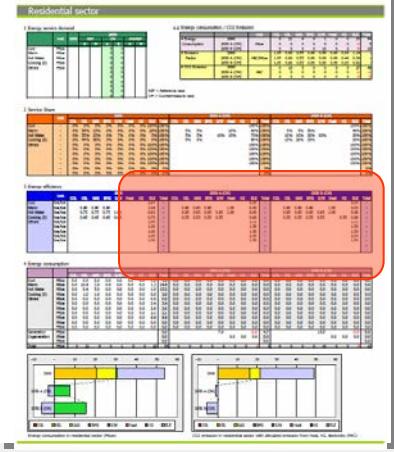




4. Service share in target year

- Set service share to fulfill the service demand
  - Assume the technology used
  - Check “total value” (=100%)

	Unit	2050 A (CM)								
		COL	OIL	GAS	BMS	S/W	Heat	H2	ELE	Total
Cool	-	0%	0%	0%	0%	0%	0%	0%	100%	100%
Warm	-	61%	8%	2%	10%	0%	3%	0%	16%	100%
Hot Water	-	0%	6%	50%	30%	0%	10%	0%	4%	100%
Cooking	-	7%	0%	1%	92%	0%	0%	0%	0%	100%
Others	-	0%	0%	0%	0%	0%	0%	0%	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%	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%

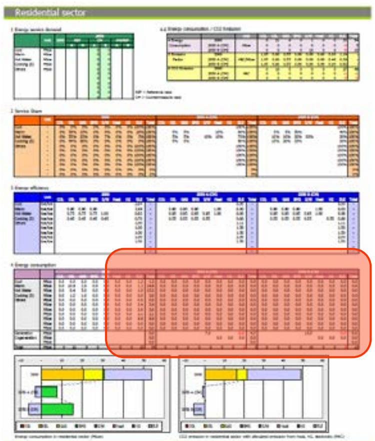


5. Energy use eff. in target year

- Set energy efficiency of each energy use in Target Year
  - Keep consistency
  - The value can be relative value (Base Year=1.00)

	Unit	2050 A (CM)								
		COL	OIL	GAS	BMS	S/W	Heat	H2	ELE	Total
Cool	toe/toe								2.00	-
Warm	toe/toe	0.90	0.70	0.70	0.90		1.00		3.00	-
Hot Water	toe/toe	0.80	0.80	0.80	0.80	1.00	1.00		1.00	-
Cooking	toe/toe	0.80		0.50	0.45	0.45			0.70	-
Others	toe/toe								1.00	-
	toe/toe									-
	toe/toe									-
	toe/toe									-
	toe/toe									-
										-
										-

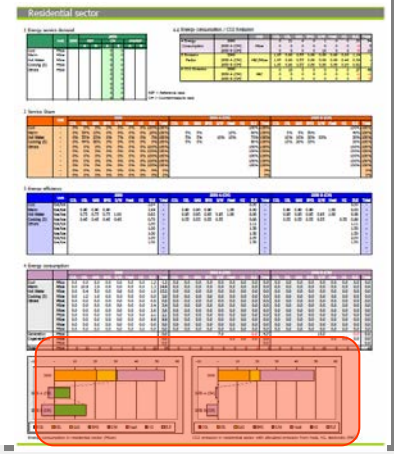
Contents



6. Energy Cons. in Target year

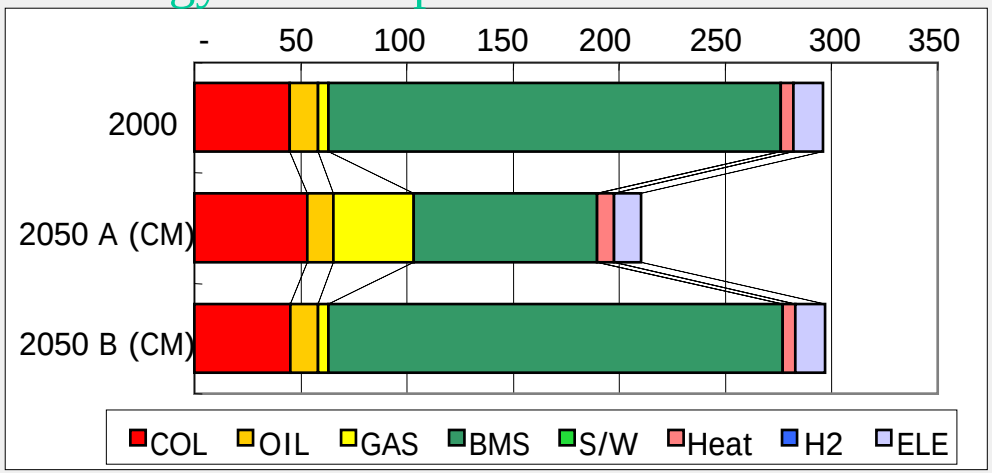
- Calculated automatically
- Additional Input
  - Generation: PV etc.
  - CHP: Fuel cells, Gas engine etc.

		2050 A (CM)								
		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	1.8	1.8
Warm	Mtoe	50.6	8.0	2.4	8.3	0.0	2.4	0.0	4.0	75.7
Hot Water	Mtoe	0.0	4.2	35.0	21.0	0.0	5.6	0.0	2.0	67.8
Cooking	Mtoe	2.5	0.0	0.5	57.0	0.0	0.0	0.0	0.0	60.0
Others	Mtoe	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0	5.0
	Mtoe	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
	Mtoe	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
	Mtoe	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
Generation	Mtoe									0.0
Cogeneration	Mtoe									0.0
	Mtoe									0.0
Total	Mtoe	53	12	38	86	0	8	0	13	210

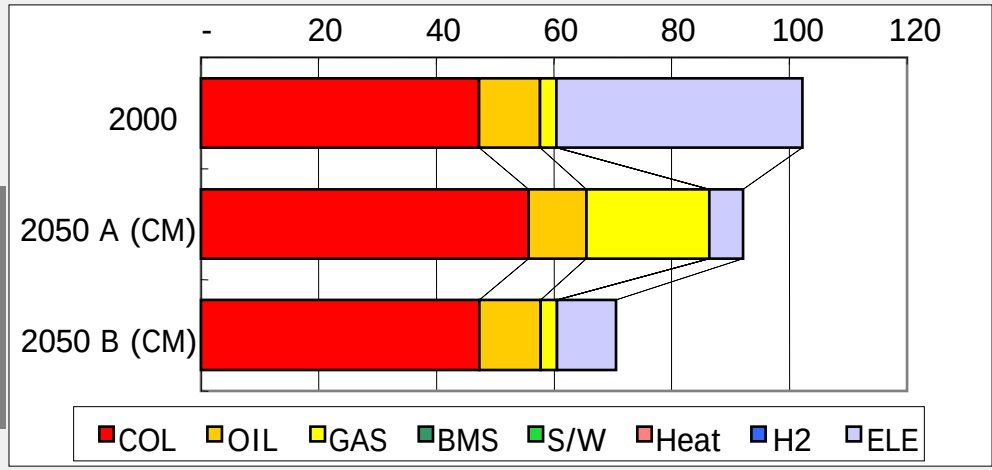


7. Check the results

Energy Consumption



CO2 Emission

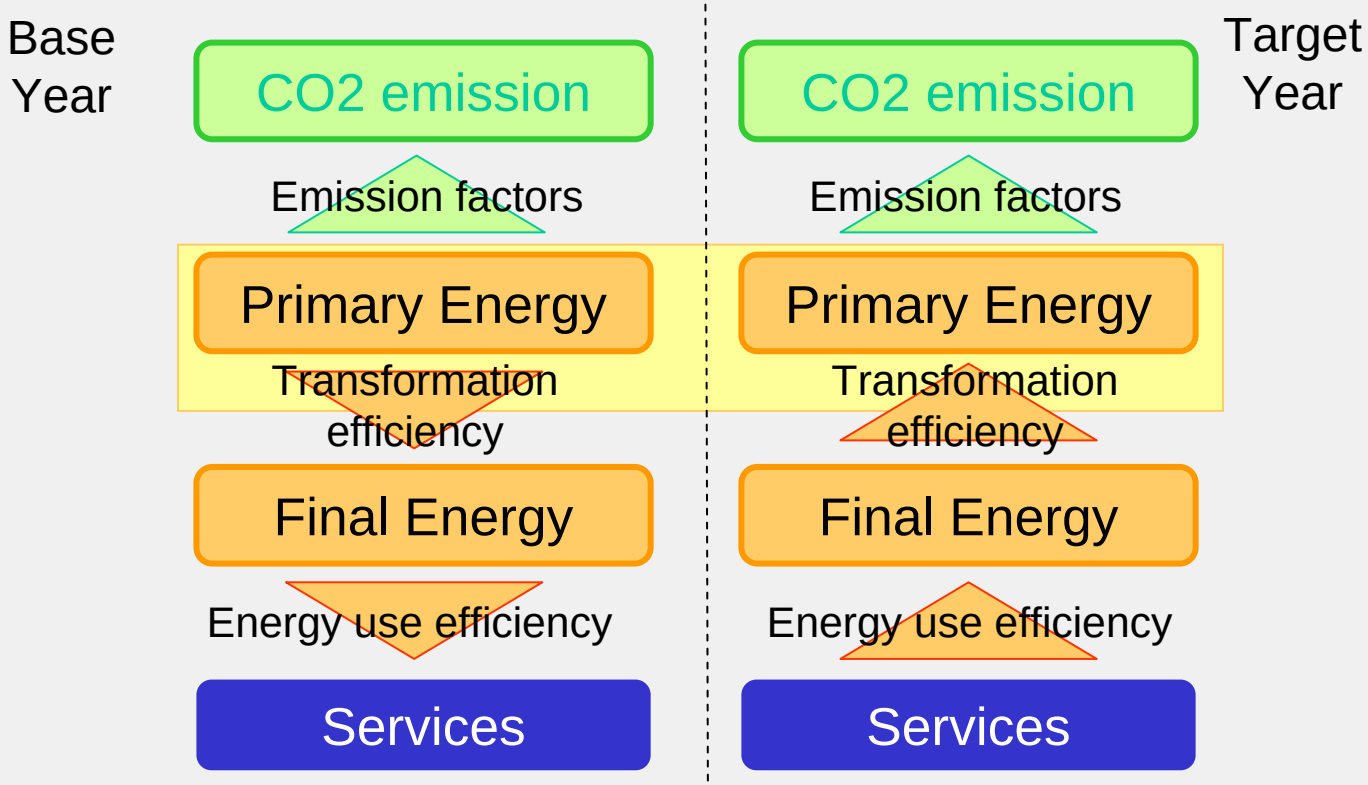


Note: Before implement CO2 analysis, assumption of energy transformation needed to be made

Contents

Transformation Sector

Transformation Sector



5. Calculate CO2 emissions by multiplying "emission factors" of each energy

Electricity Generation

- Goal: Primary energy consumed for electricity generation in target year.

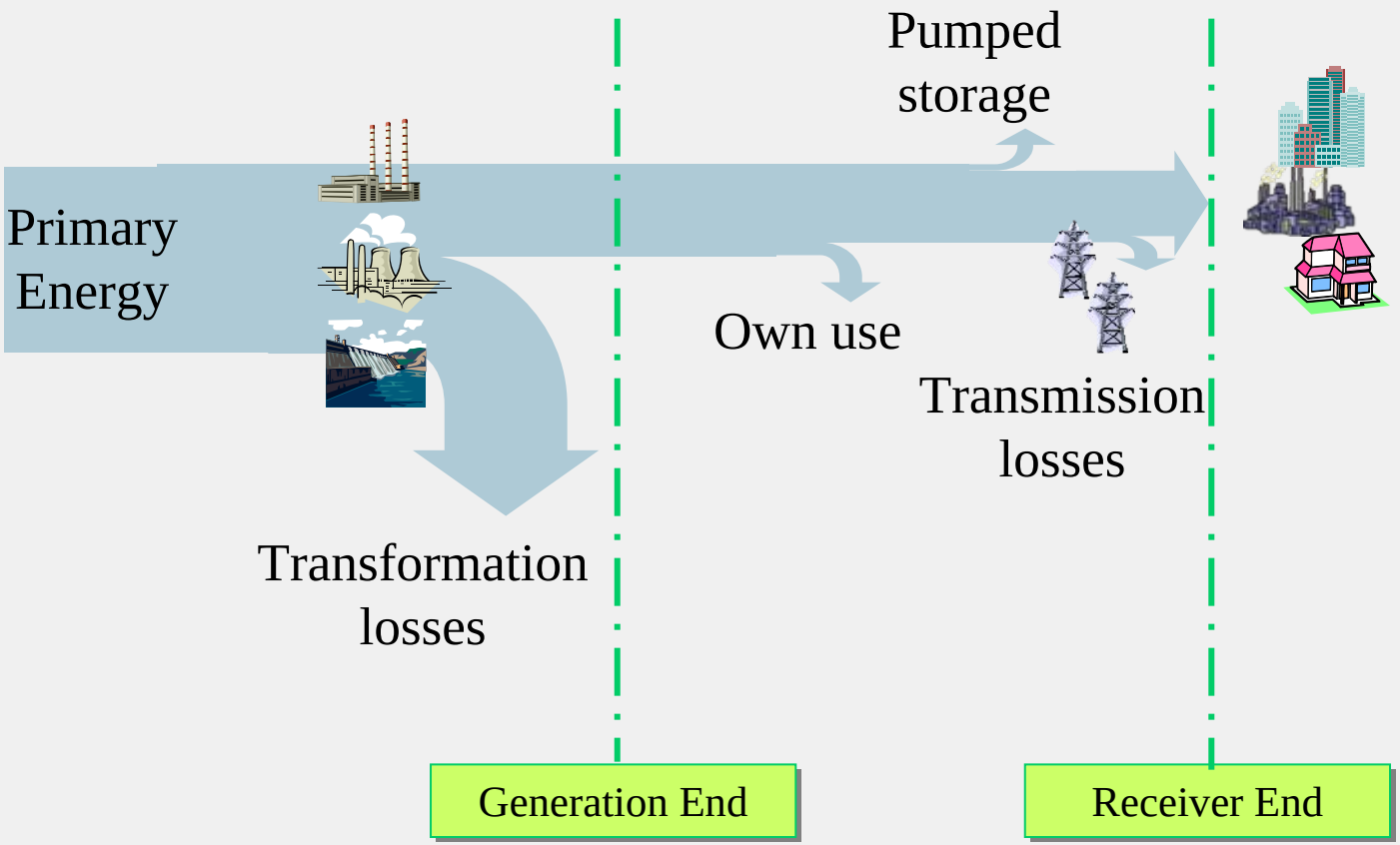
Power generation sector

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	98	88	86	88	86	98	98	98	98
2. Difference between demand and supply										
	Mtoe	12.16	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	103	88	86	88	86	98	98	98	98
Transmission Loss		6.84%	5.31%	5.31%	5.3%	5.3%	5.3%	5.3%	5.3%	5.3%
4. Electricity supply before tranmission										
Electricity supply	Mtoe	111	93	91	93	91	104	104	104	104
Pumped storage (PS)										
Ele. demand of PS	Mtoe	0	1	1	0	0	1	1	0	0
Efficiency		100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Generation of PS	Mtoe	0	1	1	0	0	1	1	0	0
Own use										
Own use in plant	Mtoe	6	4	4	5	5	5	4	6	6
Own use rate										
COL		6.0%	6.0%	6.0%	6.0%	6.0%	6.0%	6.0%	6.0%	6.0%
GAS		4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%
OIL		5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%
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%

P
S

Electricity Generation

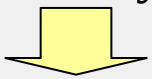


Electricity Generation

- Data setting for reference year
  - Electricity demand at receivers end (EBT or "EB_SD")
  - Electricity Transmission (& distribution) losses (EBT)
  - Efficiency of pumped storage (Def: ratio between consumed energy while pumping and generated energy)
  - Own use rate of electricity plant (EBT; Only aggregated data. Detailed information needed)
  - Electricity supply at generation end (EBT)
  - Primary Energy Consumption (EBT)

Electricity Generation

- Data setting for target year (visions)
  - Transmission losses
  - Efficiencies of pumped storage
  - Own use rate
  - Mixture of energy
  - Thermal efficiency



- Click “Solver”!!
  - “Electricity supply at generation end” is controlled automatically so that the electricity demand of the end-user would be fulfilled
  - Primary energy supply for electricity generation is calculated
  - Check if differences between demand & supply; 0

Note: Solver

The Solver Add-in is an Excel add-in (add-in: A supplemental program that adds custom commands or custom features to Microsoft Office.) program that is available when you install Microsoft Office or Excel. To use it in Excel, however, you need to load it first.

1. On the **Tools** menu, click **Add-Ins**.
2. In the **Add-Ins available** box, select the check box next to **Solver Add-in**, and then click **OK**. **Tip** If **Solver Add-in** is not listed, click **Browse** to locate it.
3. If you see a message that tells you the Solver Add-in is not currently installed on your computer, click **Yes** to install it.
4. Click **Tools** on the menu bar. When you load the Solver Add-in, the **Solver** command is added to the **Tools** menu

Other energy transformation

- Click “EB_SD” sheet
- EBT (demand) is there !!

Name	Contents
EB_SD	Energy balance table (Countermeasures in energy enduse & transformation sector)
EB_S	Energy balance table (Countermeasures in energy transformation sector)
EB_D	Energy balance table (Countermeasures in energy enduse sector)
EB_0	Energy balance table (No counter measures = Reference case)

Other energy transformation

- Excluding electricity generation (already calculated)
- CCS: Energy use for CCS (a) & amount of carbon captured in appropriate unit (b) .
- Heat & Hydrogen: Put the negative value of heat used in demand side (c) and inputs of feedstock
- Coal/Oil/Gas: Losses during refining processes etc.

2000

	COL	OIL	GAS	BMS	NUC	HYD	S/W	Heat	H2	ELE	Total	'90=100
Energy Balances (Mtoe)												
Power Gnr.	275	12	2	1	4	19	0			-100	213	
CCS					(a)						0	
Heat	35	4	1					-25			15	
Coal/Oil/Gas	31	3									34	
Hydrogen											0	
Industrial	177	69	12	0			0	19	0	63	339	
Residential	45	13	5	213			0	6	0	14	296	
Commercial	0	15	9	0			1	0	0	22	46	
Trans. Prv.	6	67	0	0			0	0	0	1	74	
Trans. Frg.	0	0	0	0			0	0	0	0	0	
Enduse	227	164	26	213			1	(b) 25	0	100	756	
Total	569	182	28	214	4	19	1	0	0	0	1,017	
Feedstock in total		2										
Emission Factor (MtC/Mtoe)	1.05	0.80	0.55	0.00	0.00	0.00	0.00	-	-	-		
CO2 Gnr. (MtC)	597	145	16	0	0	0	0	-	-	-	757	267
CO2 Dsp. (MtC)								-	-	-		
CO2 Ems. (MtC)	597	144.6	16	0	0	0	0	-	-	-	757	267

Contents

Analysis

Factor analysis

- Extended Kaya Identity

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

$$\frac{\Delta C}{C} = \frac{\Delta D}{D} + \frac{\Delta (E/D)}{(E/D)} + \frac{\Delta (C'/E)}{(C'/E)} + \frac{\Delta (C/C')}{(C/C')} + \text{Cross term}$$

D: Driving forces (service demand)

E: Energy Consumption

C': CO_2 emission without measures in transformation sector

C: CO_2 emission with measures in transformation sector

E/D: Energy Intensity

C'/E: CO_2 intensity in end-use sector (without measures in transformation sector)

C/C': Change of CO_2 intensity by measures in transformation sector

Data input for factor analysis

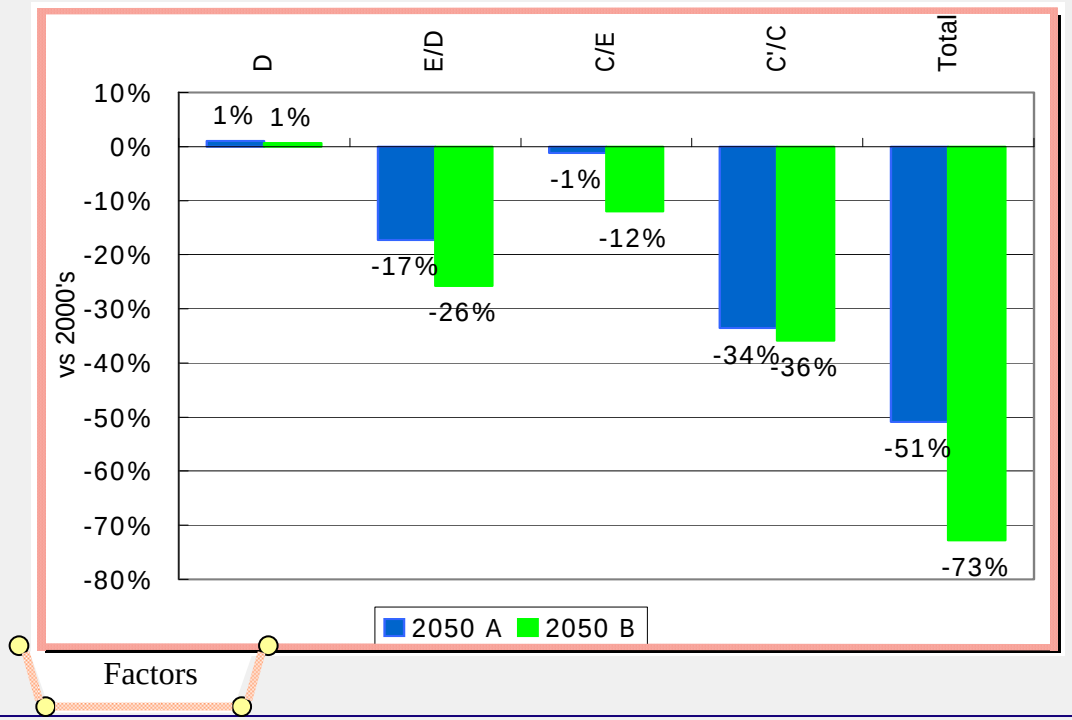
- Differentiate the contribution of CO2 reduction from supply side and demand side
- Consistent visions required

Name	Contents
EB_SD	Energy balance table (Countermeasures in energy enduse & transformation sector)
EB_S	Energy balance table (Countermeasures in energy transformation sector)
EB_D	Energy balance table (Countermeasures in energy enduse sector)
EB_0	Energy balance table (No counter measures = Reference case)

Factor analysis

- Kaya Identity

$$\frac{\Delta C}{C} = \frac{\Delta D}{D} + \frac{\Delta (E/D)}{(E/D)} + \frac{\Delta (C'/E)}{(C'/E)} + \frac{\Delta (C/C')}{(C/C')} + \text{Cross term}$$



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Please do not hesitate to ask questions!!

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Exercise 1

Data preparation

1. *Download data (EBT of your country) on your Personal Computer (Table format)*
2. *See items in row & columns, and check the definitions of the terms*
3. *Create detail dataset of Residential Sector and Passenger Transportation Sector using "Reference data.xls" in dataset folder.*
4. *Create dataset of Commercial Sector and Industial sector, Transformation Sector*
5. *Fill in energy balance table in ESS tool*
6. *If data is inappropriate*

Split energy cons. by category

		ROAD									
		Light Vehicle					Other Vehicle				
			Autos	Light trucks	Three wheels	Two wheels		Buses	Heavy trucks	Medium trucks	Commercial trucks
			TRT	TRL	TRE	TRW		TRB	TRH	TRM	TRC
Coal	TRACOA										
Methanol	TRAMET	0%					100%	100%			
Ethanol	TRAETH	0%					100%	100%			
Natural gas	TRANGA										
LPG	TRALPG	60%	70%	30%			40%	30%	30%	40%	
Gasoline	TRAGSL	80%	60%	39%	1%	1%	20%	10%	10%	40%	40%
Aviation Gasoline	TRAAVG										
Jet Kerosene	TRAJTK										
Diesel	TRADST	15%	20%	80%			85%	20%	20%	30%	30%
Heavy Fuel Oil	TRAHFO										
Electiricity	TRAELC										

		Space heating	Space cooling	Hot water heating	Refrigerators and freezers	Cloth dryer	Cooking	Cloth washers	Dish washers	Other energy uses
		RH1	RC1	RHW	RRF	RCD	RK1	RCW	RDW	ROT
Natural gas	RESNGA	40%		40%			20%			
Diesel	RESDST	50%		40%						
Heavy fuel oil	RESHFO									
Kerosene	RESKER	30%		30%			20%	20%		
Coal	RESCOA	70%		25%			5%			
LPG	RESLPG	30%		40%			30%			
Biofuels	RESBIO	30%		35%			35%			
Electiricity	RESELC	10%	10%	10%	15%	1%	5%	1%	1%	
Heat	RESHET									
Geothermal	RESGEO									
Solar	RESSOL									

Recommended category for P-trans.

- Motorbike
- Car
- Bus
- Railway
- Aviation
- Maritime