AIM/Energy Snapshot Tool (ESS)

AIM Training Workshop

Tsukuba, Japan Oct 27-31, 2008

Contents

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

Background

Steps of Japan 2050LCS study

- Energy Snap Shot tool (2 years ago)
  - Create narrative scenario (vision of 2050 LCS).
  - ESS shows us CO2 reduction quantitatively.
  - However, ESS doesn't provide us the concrete actions.

- Dozen of Actions (last year)
  - "Dozen of Actions" shows concrete policies / actions to realize LCS.
  - Various candidates of action are described.

Steps of Japan 2050LCS study

- "Dozen of Actions" shows us what kind of actions are required to realize LCS, but we still don't obtain quantitative information (cost of actions / required term for implementing actions).

- Back Cast(ing) Model (this year)
  - BCM provide us following information quantitatively.
  - Which policies / actions will be introduced
  - When will those actions should be introduced
  - How mach will we have to pay for

Steps of Japan 2050LCS study

- ESS
  - Provide CO2 reduction amount (potential) in 2050.
- Dozen of Actions
  - Provide candidates of actions to realize LCS in 2050.
- BCM
  - Give quantitative bases to the actions. (implementing cost, timing of introduction, CO2 reduction amount, etc.)

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

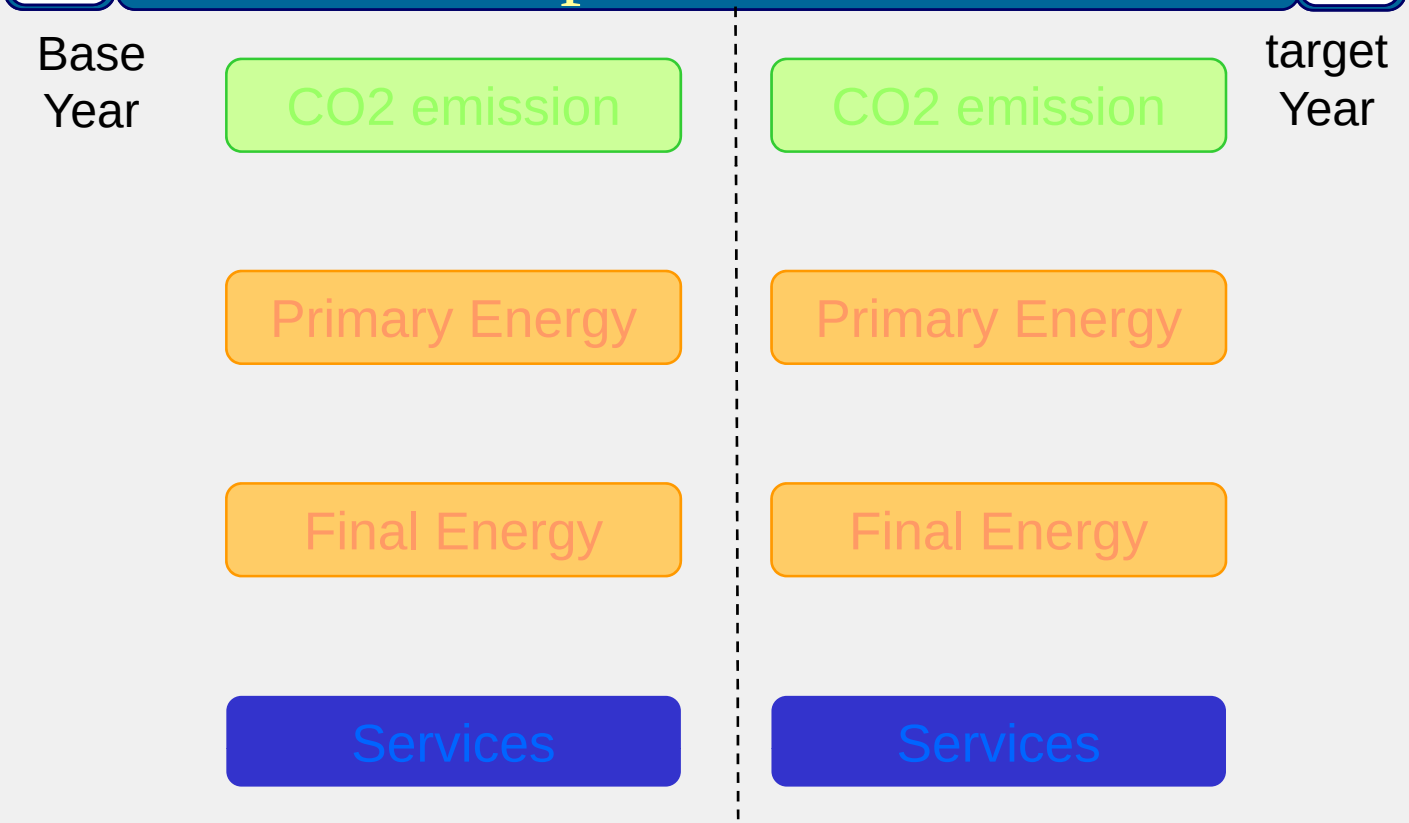
Losses

Technology producing
the demanded services

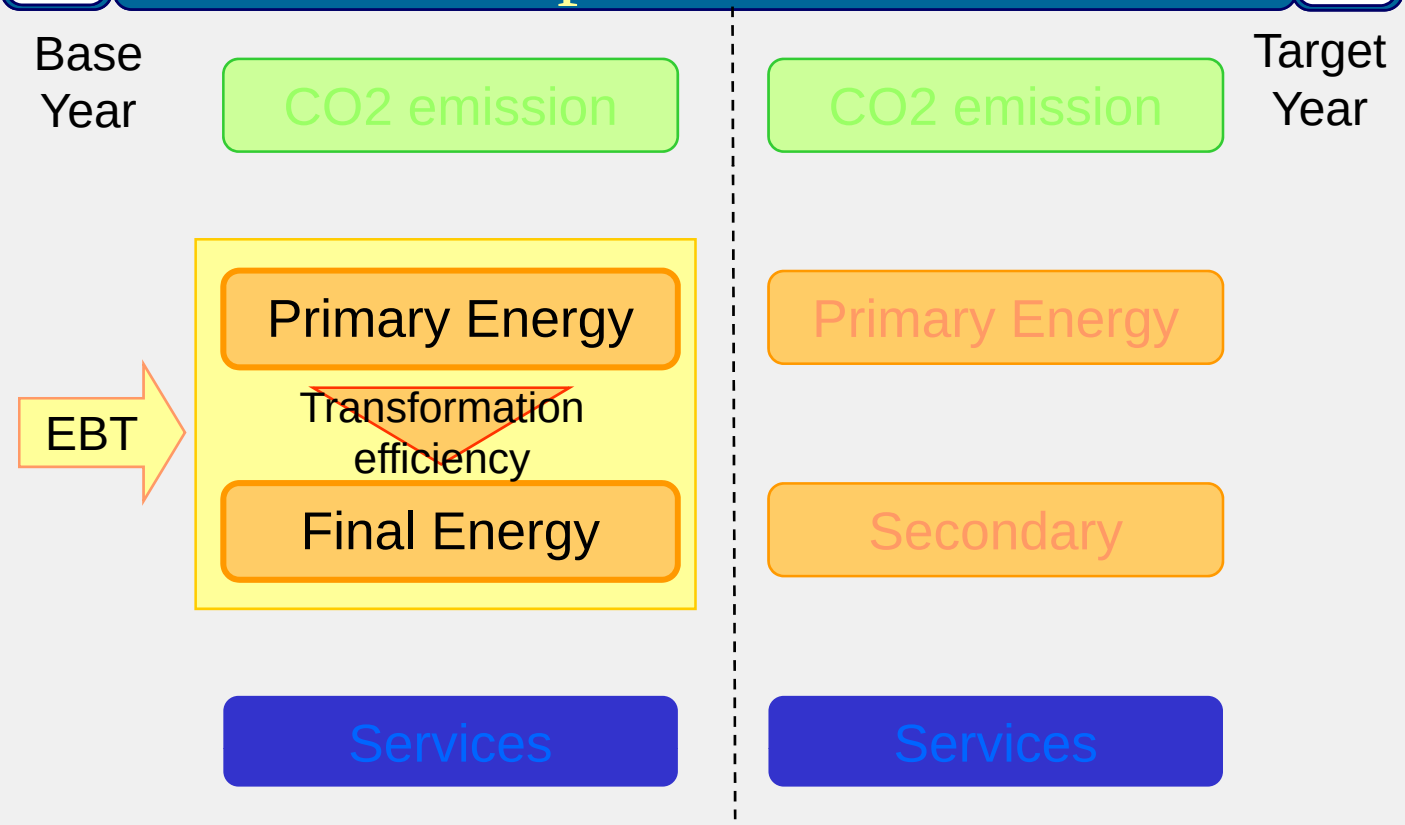
Services

Structure & Flow

Calculation processes

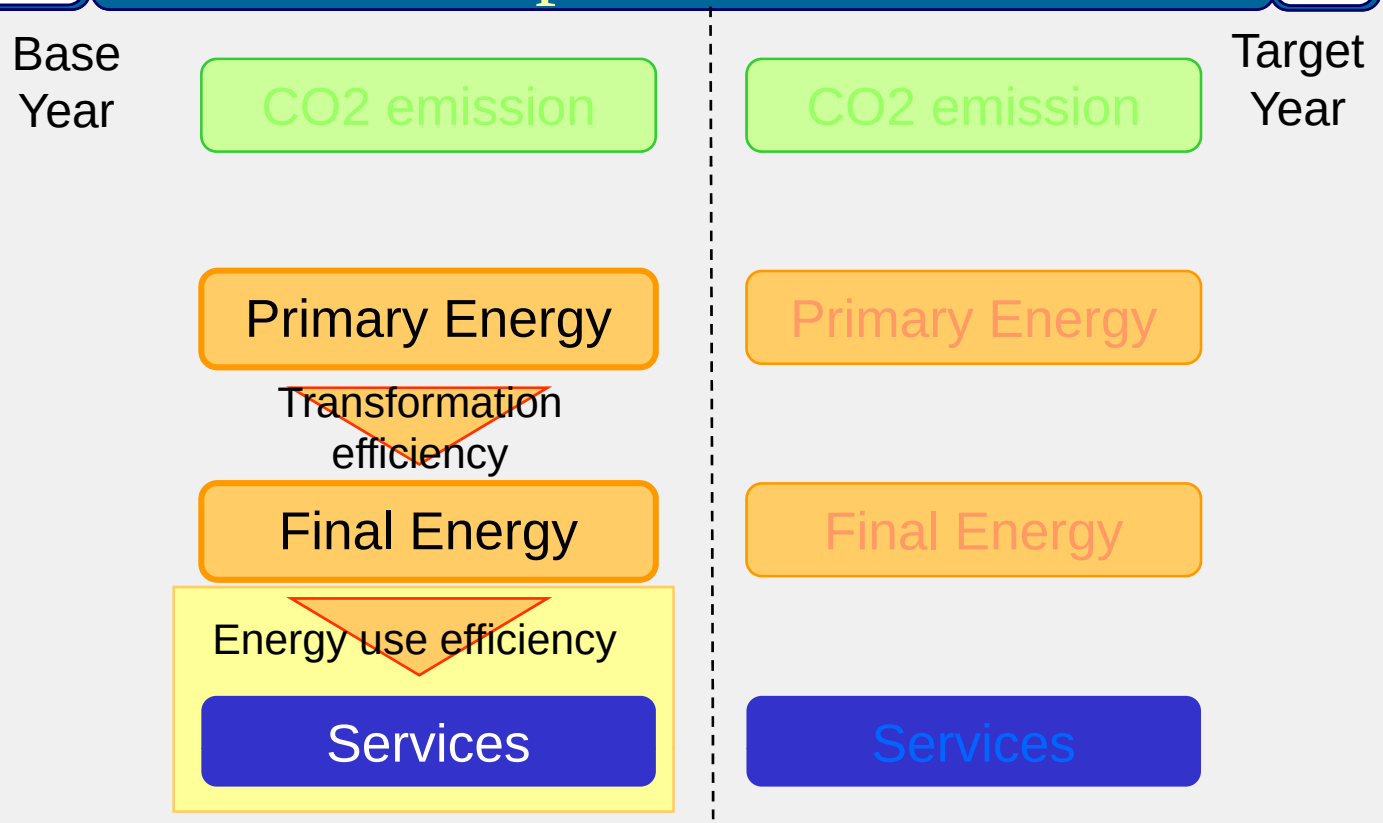


Calculation processes



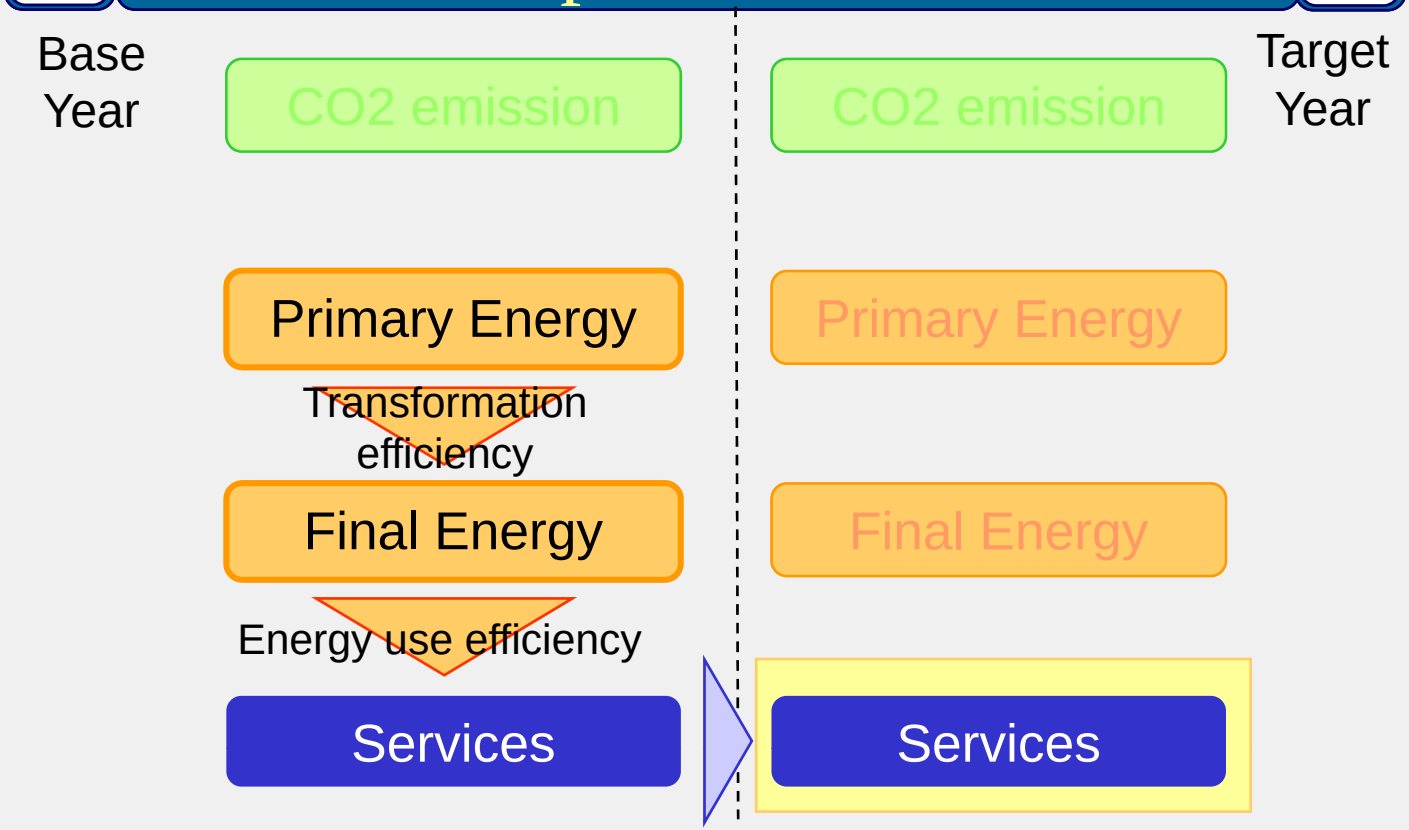
1. Obtain EBT from national statistics etc. (Base Year)

Calculation processes



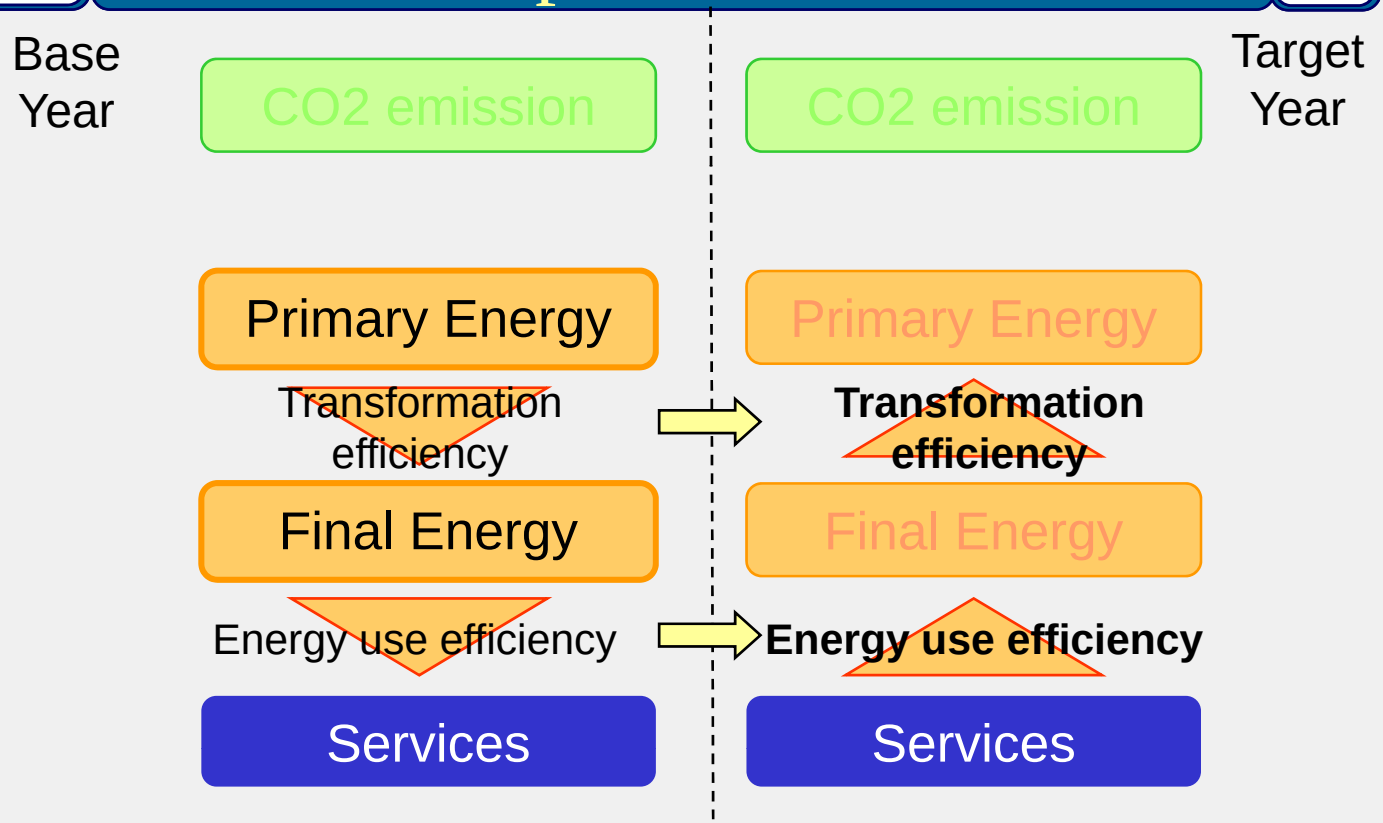
2. Set energy use efficiency & Services demand
   Services/Final Energy (C/S) ratio (Base Year)

Calculation processes



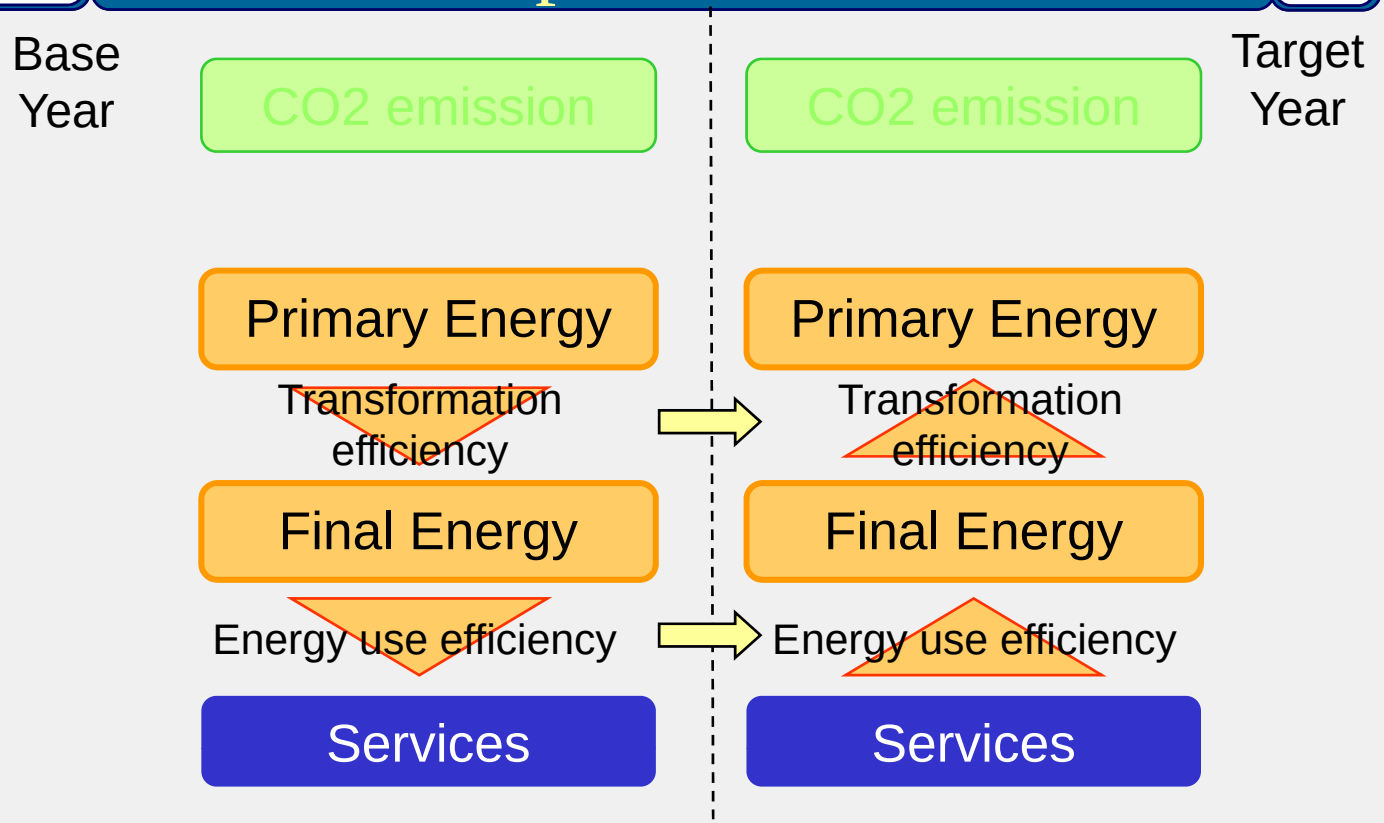
3. Assume changes in “Energy service demand” in Target Year (Scenarios or Visions)

Calculation processes



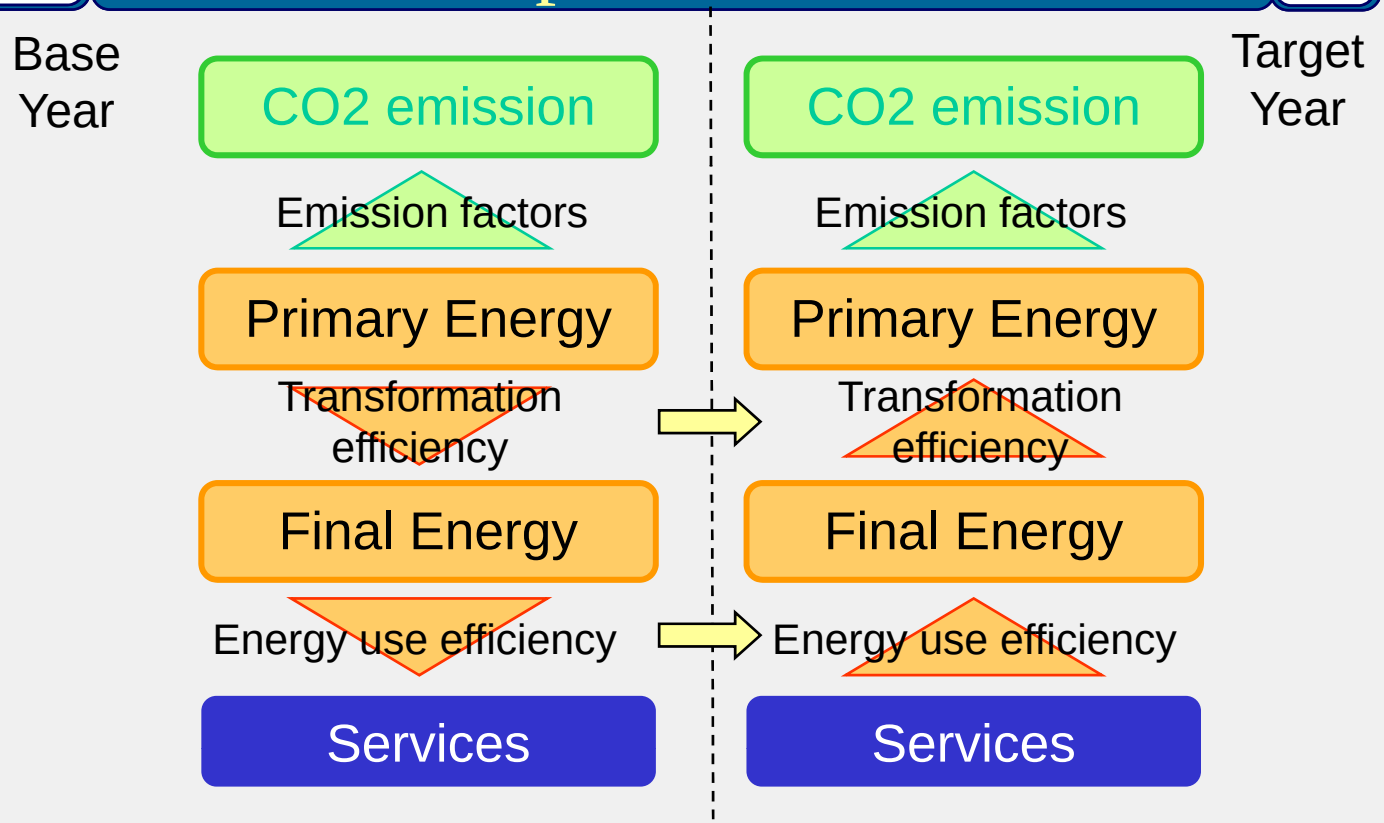
3. Assume changes in parameters in Target Year (Scenarios or Visions)

Calculation processes



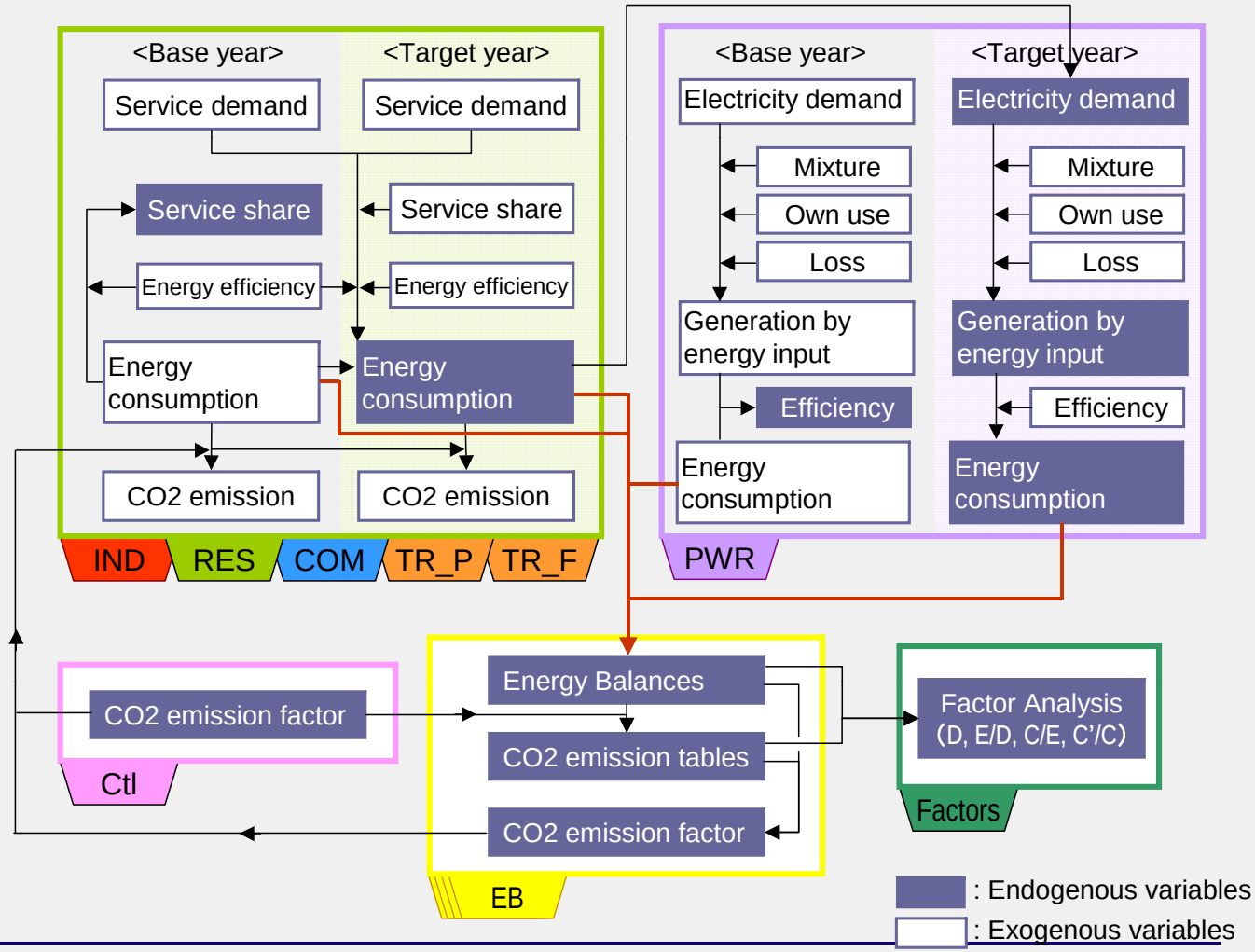
4. Calculate energy Primary Energy and Final Energy in Target Year

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
- Commercial
- Transportation_P
- Transportation_F
- Industry

Residential sector

1 Energy service demand

	Unit	2000	2050 REF A	2050 REF B	2050 CM A	2050 CM B	2050 CM/REF A	2050 CM/REF 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		

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

2000

	Unit	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%
	-	0%	0%	0%	0%	0%	0%	0%	0%	0%

2050 A (CM)

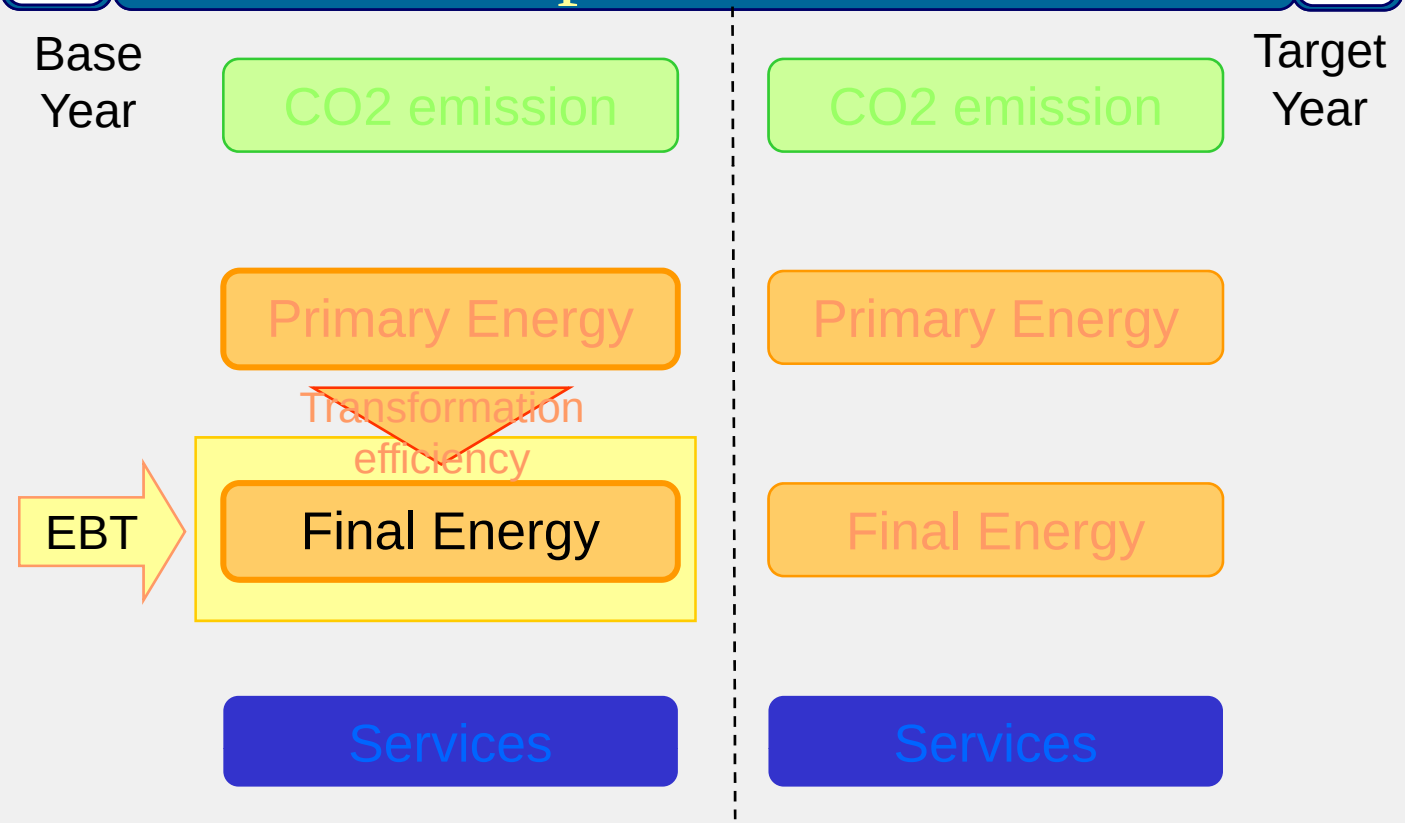
	COL	OIL	GAS	BMS	S/W	Heat	H2	ELE	Total
Cool	0%	0%	0%	0%	0%	0%	0%	100%	100%
Warm	61%	8%	2%	10%	0%	3%	0%	16%	100%
Hot Water	0%	6%	50%	30%	0%	10%	0%	4%	100%
Cooking	7%	0%	1%	92%	0%	0%	0%	0%	100%
Others	0%	0%	0%	0%	0%	0%	0%	100%	100%
	0%	0%	0%	0%	0%	0%	0%	0%	0%
	0%	0%	0%	0%	0%	0%	0%	0%	0%
	0%	0%	0%	0%	0%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

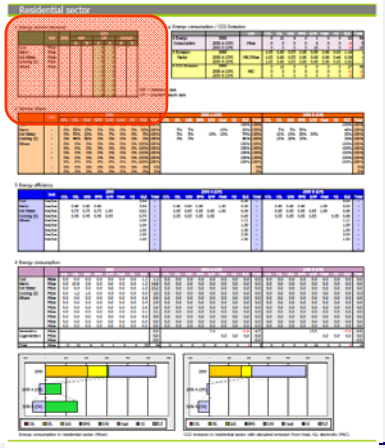
2050 B (C

	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
	0%	0	0	0	0

Demand Setting (Residential Sector)

Calculation processes



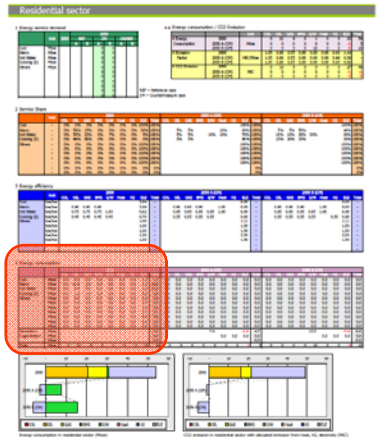


0. Preparation

- 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

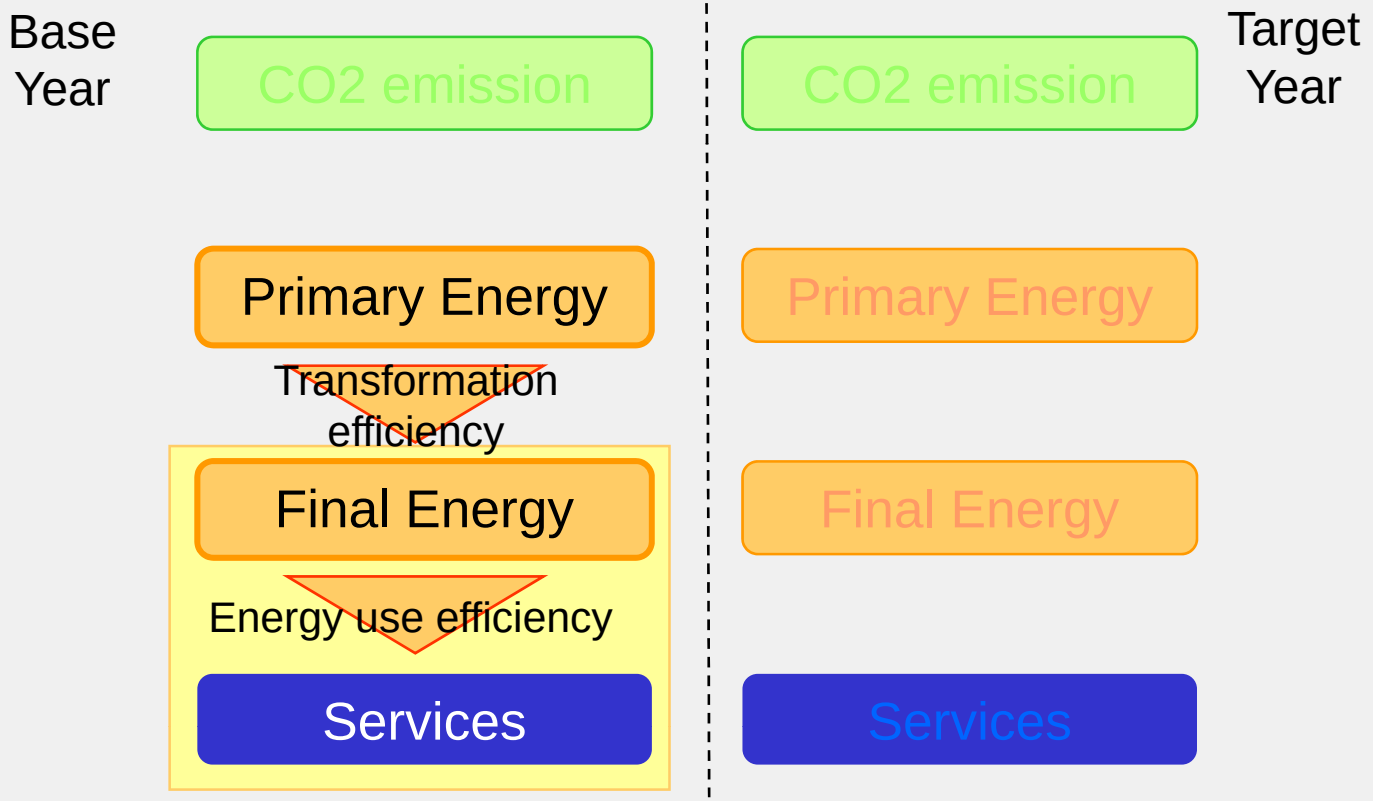


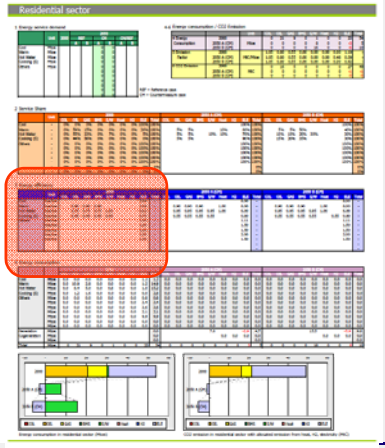
0. Energy Cons. in base year

- 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



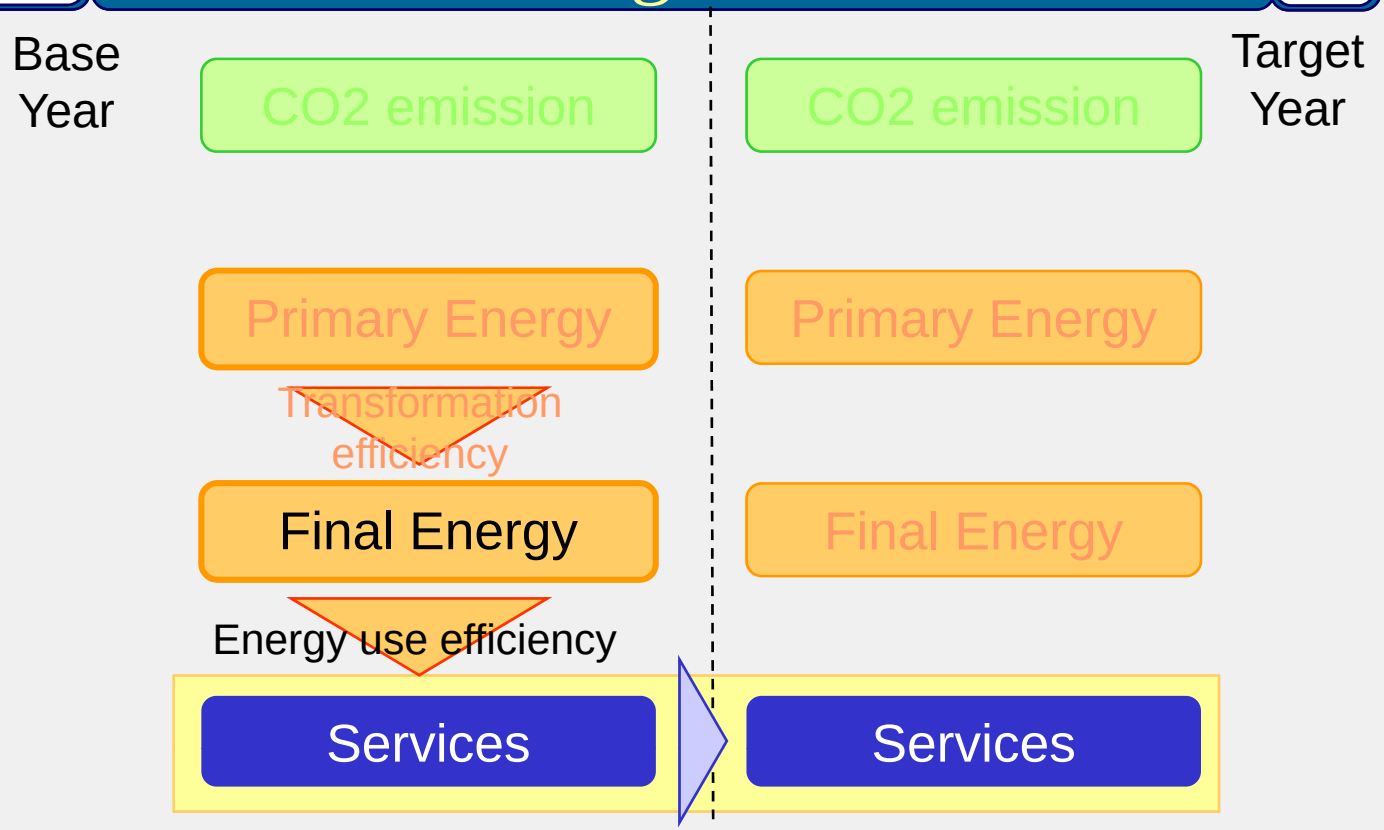


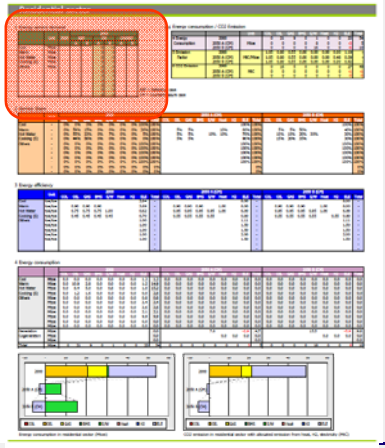
2. Energy use eff. in base year

- 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



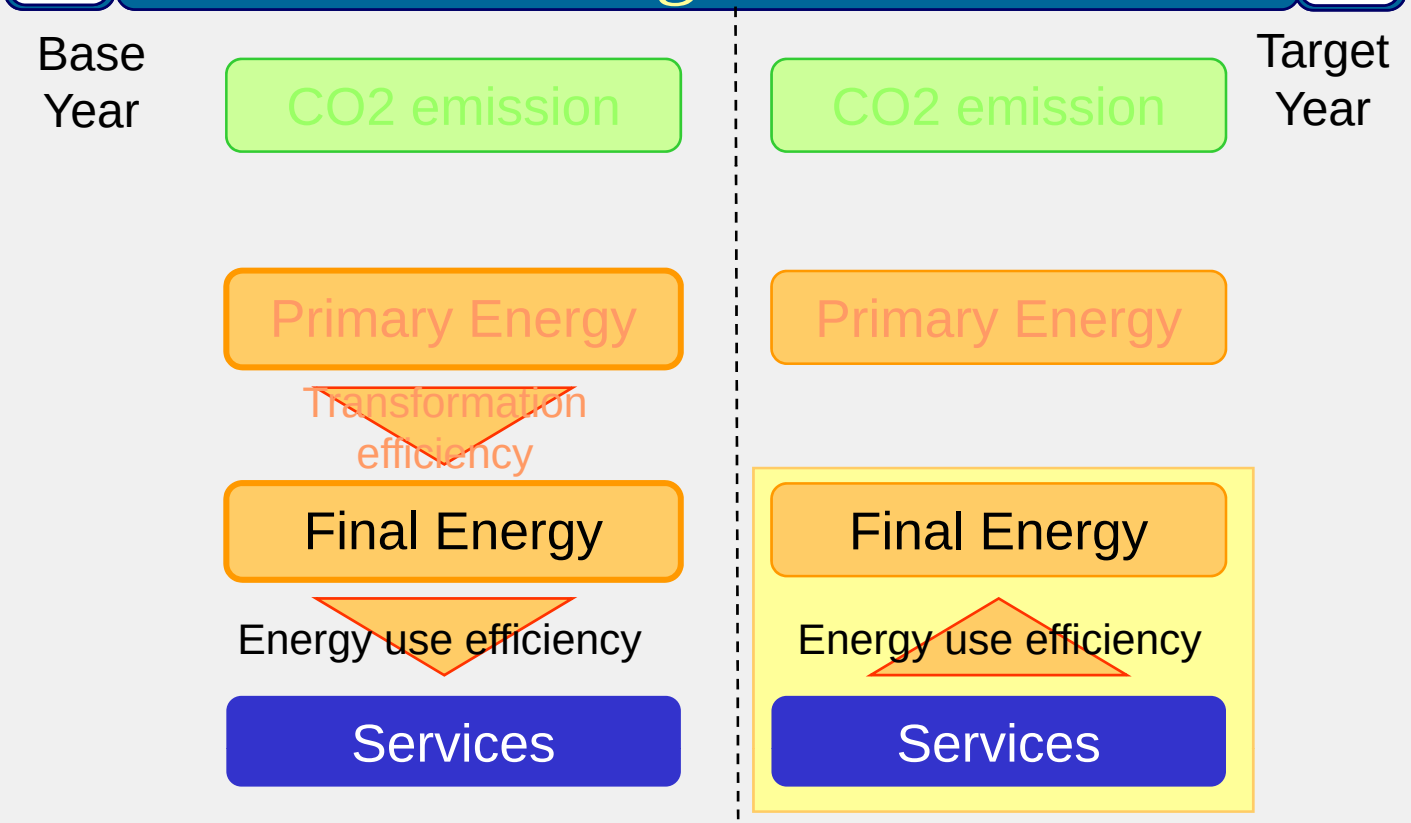


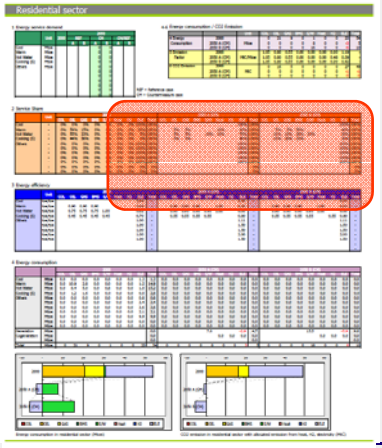
3. Service Demand

- Service demand in base year
  - Service demand (Mtoe) = Energy consumption*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

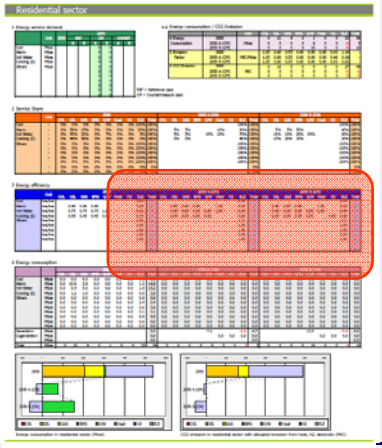




4. Service share in target year

- 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%

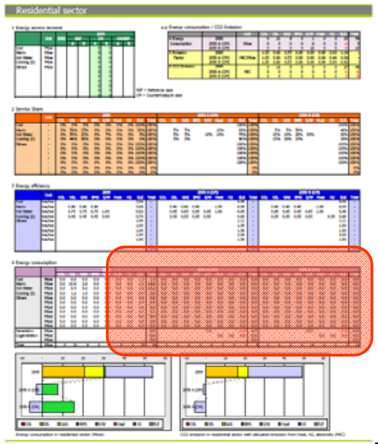


5. Energy use eff. in target year

- 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

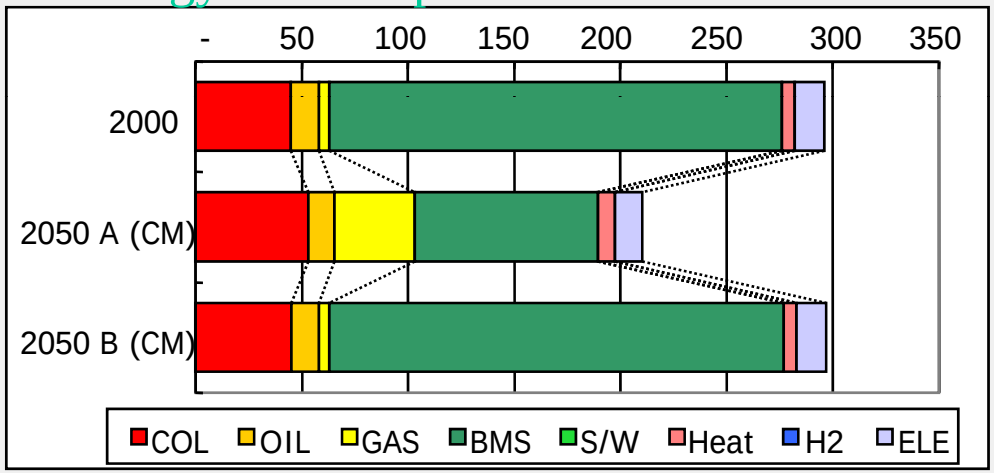
- Calculated automatically
- Additional Input
  - Generation: PV etc.
  - CHP: Fuel cells, Gas engine etc.

		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

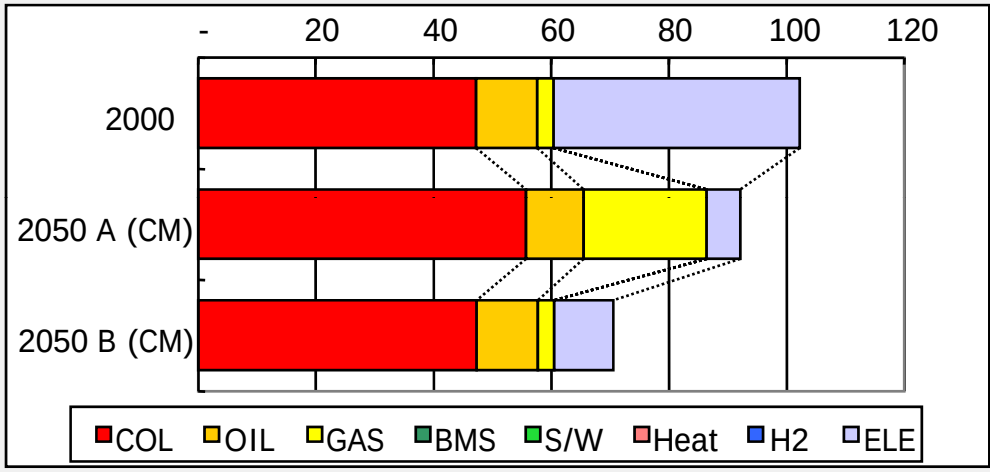
Contents

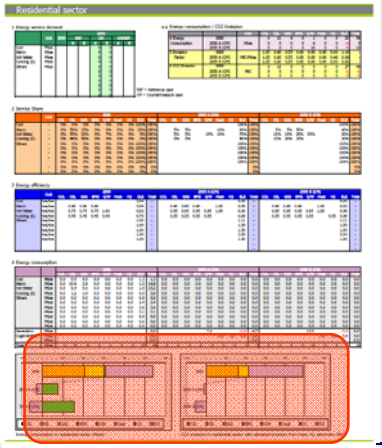
7. Check the results

Energy Consumption



CO2 Emission

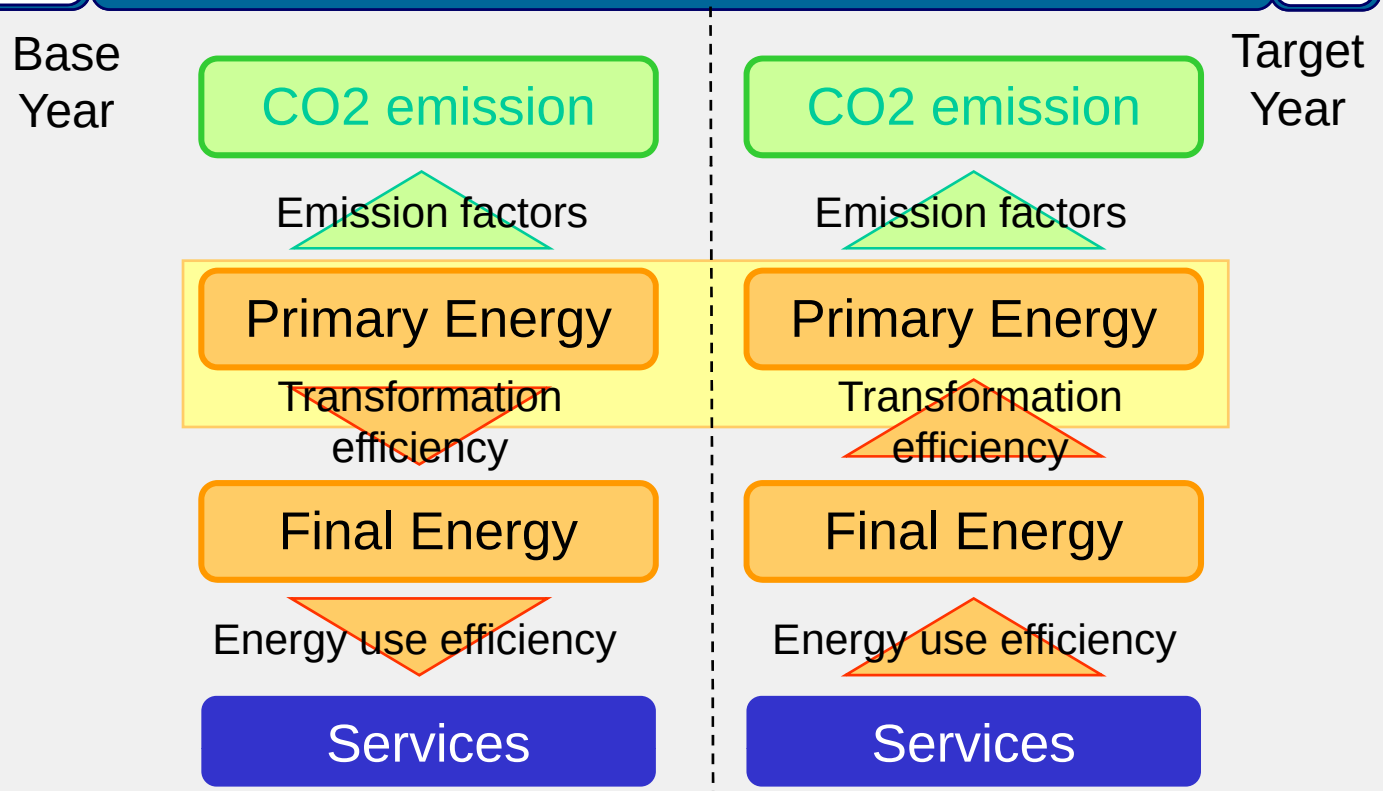




Note: Before implement CO2 analysis, assumption of energy transformation needed to be made

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.

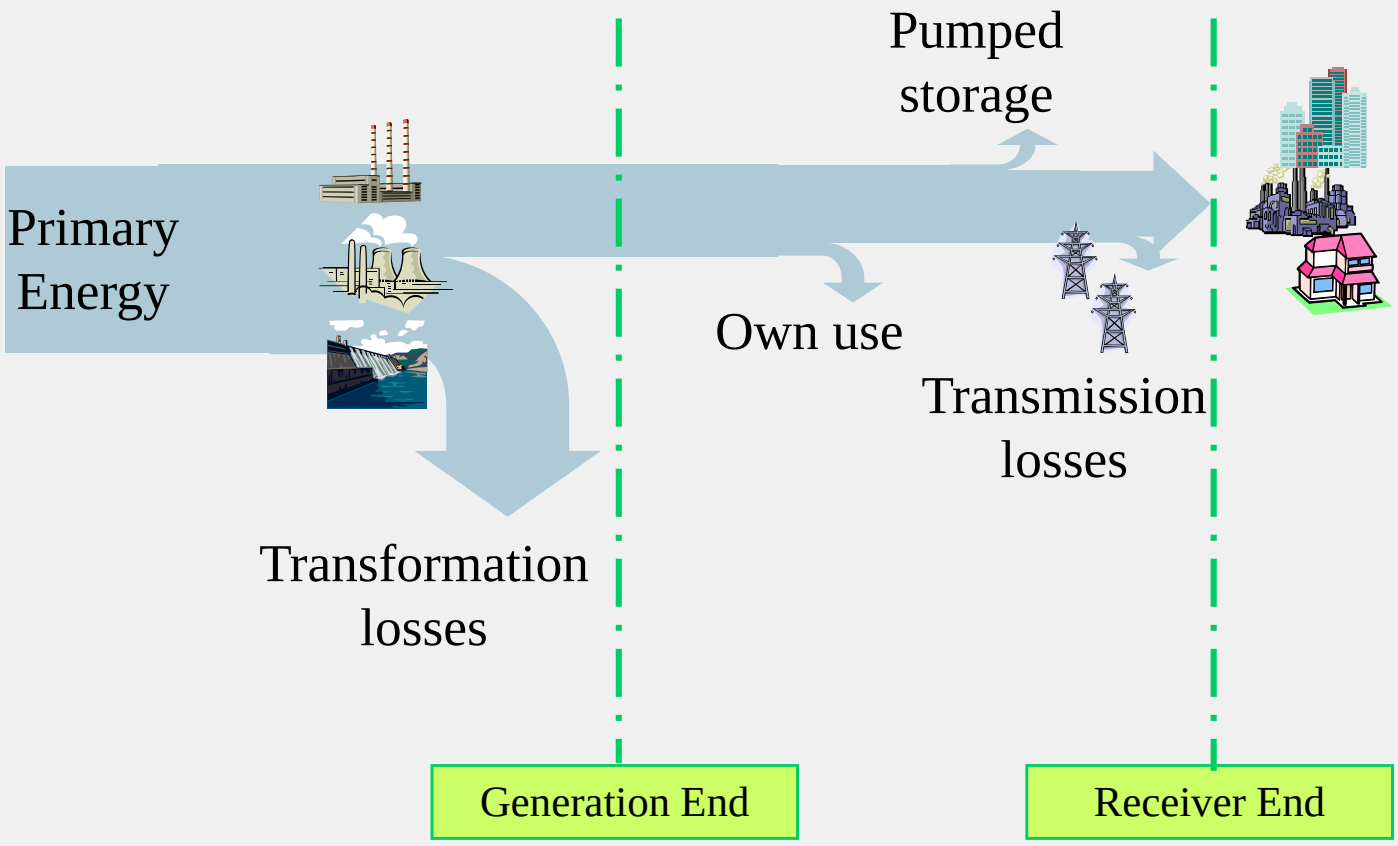
Power generation sector

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%

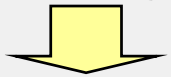
P
S

Electricity Generation



Electricity Generation

- Data setting for 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

Electricity Generation

Power generation sector

Solver

Here!

		2000	2050							
			Supply & Demand		Only Demand		Only Supply		No	
			A	B	A	B	A	B	A	B
1. Electricity demand a										
			88	86	88	86	98	98	98	98
2. Difference between										
	Mtoe	12.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
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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%

Electricity Generation

- Data setting for target year (visions)
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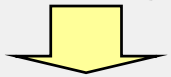


- Click “Solver”!!
  - “Electricity supply at generation end” is controlled automatically so that the electricity demand of the end-user would be fulfilled
  - Primary energy supply for electricity generation is calculated
  - Check if differences between demand & supply; 0

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

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

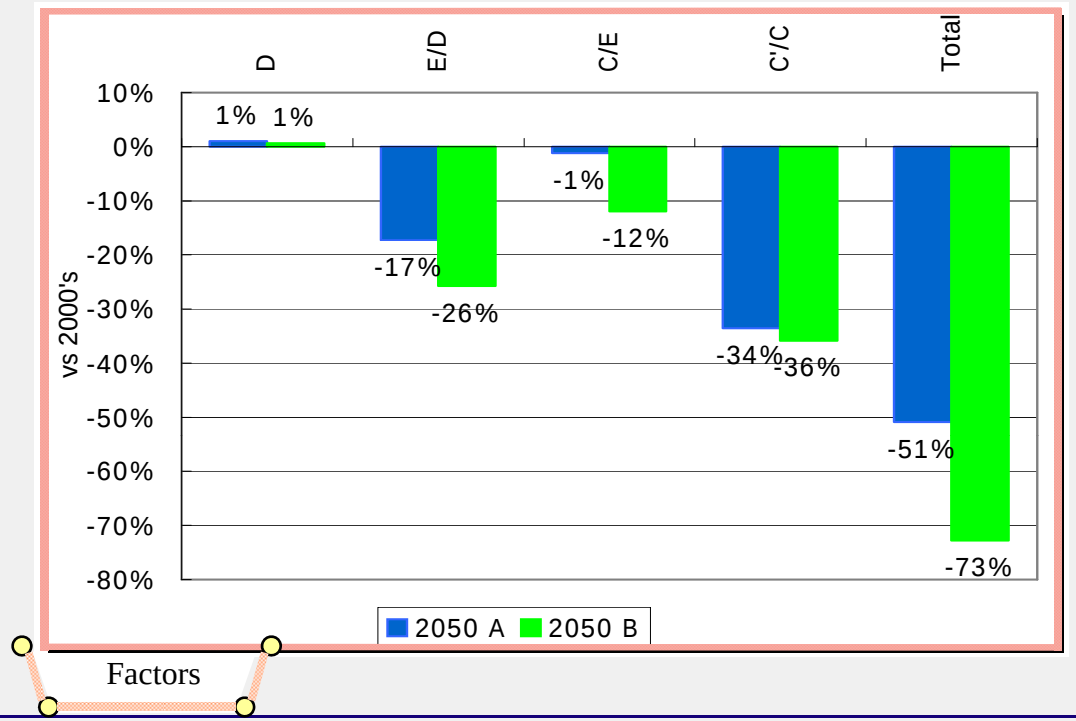
C'/E: CO_2 intensity in end-use sector (without measures in transformation sector)

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

Factor analysis

- Kaya Identity

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



Exercise

Please follow my work.

Exercise

Create some scenarios and express them by using ESS.

Ex1: Create renewables-dependent society.

(→ increase share of renewable energy and check the result.)

Ex2: Create electricity-dependent society.

(→ increase share of electricity use and check the result.)

Ex3: Society sustained by high technology.

(→ set very high energy efficiency in 2050.)

Ex4: Society with low carbon power plants.

(→ change thermal efficiency / fuel mix in power sector drastically)