Analysis of GHG Reduction Tool in Domestic Power Sector by Using TIMES Model

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TIMES Model

- MARKAL-TIMES Model characteristics
  - ➢ Based on the flow of energy and materials

Name	TIMES	Analysis model for energy system(ETSAP) of IEA
Char.	Bottom-up Optimization	Cost-minimized energy system
	dynamic	Optimization though long period
	Partial Eq. approach	Model establishment to meet final demand
Target Fn.	Cost Fn.	Minimization of Cost Fn.
Components	Target Fn.	Discounted total cost (about tech.)
	Constraints	Supply-demand condition/ CO2 emission
	Deterministic Var.	Energy supply, Activity of Tech.

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TIMES model

- TIMES model
  - Bottom-up model: using technological definition and specifications
  - Analysis on the effect to cost and energy supply of technological change.
    - Using in the analysis on GHG emission reduction tool and potential, cost
    - Technological Var: Availablity, Technical life, Heat/Elec. Ratio, etc.
  - Energy & Material analysis – Spceially useful in the industry sector analysis

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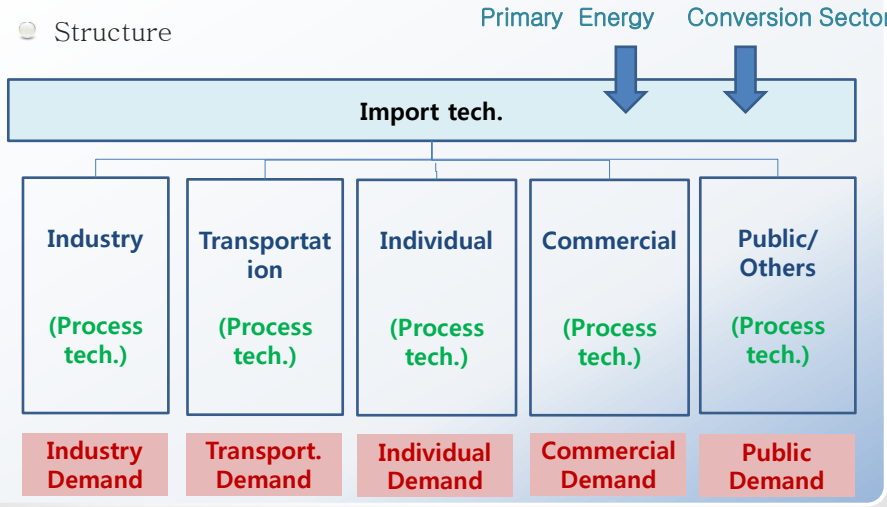
Basic Structure(National)

- Structure



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Power Sector modeling

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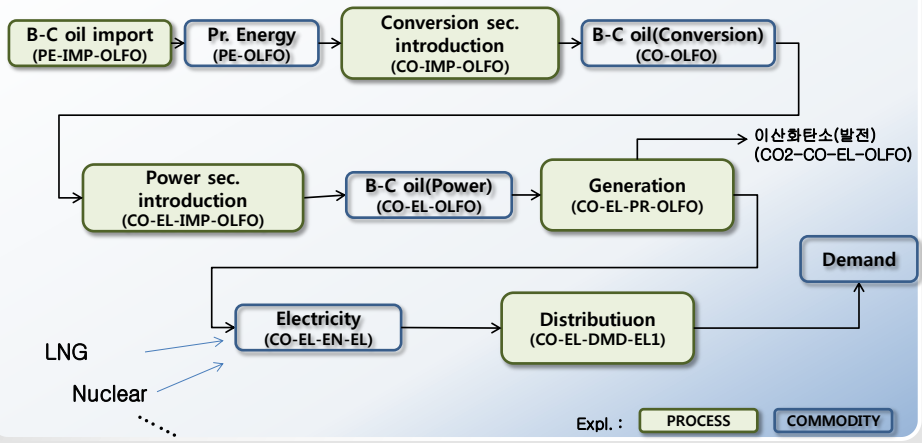
Power Sector

- Part of National TIMES Model
  - ➢ Very simple structure
    - Simple competitive pattern(between technologies)
    - No materials flow
    - Little room for using optimization(tight national plan in Korea)
  - ➢ Part of KPX(Korea Power Exchange) Projects
    - Basic methodology id WASP(KPX)
    - TIMES is a just auxiliary approach
    - Focus on the structure of power sector model

Power Sector

- Power Sector Structure(ex. B-C oil)



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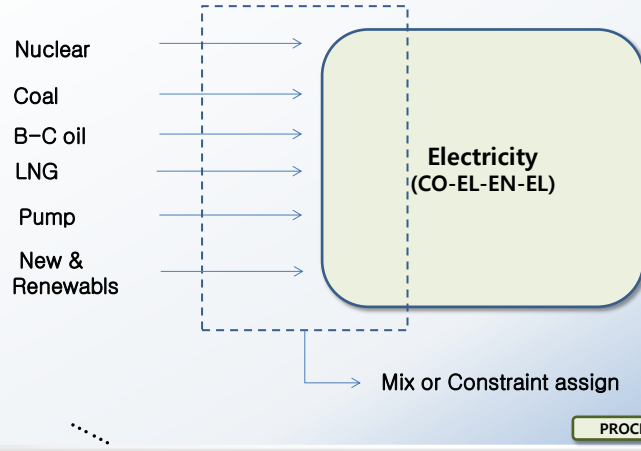
Power Sector

- Simple structure



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Basic Premise

- Premise of Analysis
  - Reference price(2010) – real price
    - Fixing price of resources
  - Discount rate: 5.5%(refer public investment project analysis)
  - Time Period: 2010~2050(5 year interval)
    - Present only the result of 2020(Target year)
  - Unit
    - Energy: PJ, Cost: M$, Capacity: GW
  - Demand based on long-term energy demand prospect(KEEI)
    - This analysis was the part of KPX project
  - Generation Facility: Efficiency, Availability, Investment Cost, O&M cost, Internal Energy Consumption

Basic Premise

- Demand Prospect

Year	Demand(GWh)		
	5th National Plan	6th National Plan	Demand Prospect(temp.)
2013	482,400	485,428	485,154
2015	520,842	526,356	526,966
2020	598,221	630,964	627,475
2025	-	733,060	708,765
2027	-	771,007	738,573

  - 5th plan -> 6th plan: Demand increase
  - Long-term Demand Prospect(KEEI) is similar to 6th plan

Basic Premise

- Fuel price and Emission coefficients

2010 Reference price (M$/PJ)				Emission coeff.(1,000CO2t/PJ)	
Anthracite Coal	5.23	Nuclear	0.304	Anthracite Coal	108.9
Bituminous Coal	4.18	By-gas	13.69	Bituminous Coal	95.0
B-C oil	15.71	Waste	1.06	B-C oil	76.3
LNG	13.69			LNG	56.5

- Demand Prospect

	2010	2020	2030	2040	2050
Demand(GWh)	434,160	627,475	779,061	889,779	973,360

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Generation Tech.

- Technologies and Categorization

Category	Technologies
New & Renewables	Hydro, Solar PV,, Wind, Waste, By-gas, Biomass, Ocean, Fuel-cell, IGCC
Coal	Bituminous Coal
Petroleum	B-C oil
Gas	LNG(including complex)
Pump	Pump
Nuclear	Nuclear

- Internal consumption rate : 4.2%(2010)
- Transmission & Distribution loss: 3.99%(2010)

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GHG Reduction Tool

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GHG Reduction Tool

- GHG reduction tool in power sector

Tool	Contents
Demand reduction (Target demand)	Target demand by demand management - Passive : '20 demand reduction 6.4% - Active : '20 demand reduction 20%
Improve mix	Control the mix of coal and LNG - Decrease coal , increase LNG
New tech.	New tech. introduction in Coal & LNG power and CCS introduction - Conservative: USC, LNG H-class introduction(based on 6th plan - Middle: Substitute 5% of existing facilities to new tech. - Progressive: Middle + CCS introduction 5% of existing facilities * absorption rate : 90%

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GHG Reduction Tool

- GHG reduction tool in power sector
  - ➢ Reduction Target
    - 26.7%(2020) of BAU, only in power sector (excluding the effect of other sectors)
  - ➢ Considering reality in technologies & demand
    - 20% demand reduction seems to be unrealistic
    - Time and level(percentage) of introduction new tech. based on the discussion of experts(KPX, KIER)
  - ➢ Mix improvement to meet CO2 constraint
    - Additional reduction tool to meet the target

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Result of Analysis

Scenario Analysis

- Demand reduction scenario

Scenario	Composition	GHG			
		MCO2t		Reduction rate (excluding indirect emission)	$/CO2t
		emission	reduction		Reduction Cost (excluding demand re. cost)
Baseline		307.0	-	-	-
Demand reduction	Demand reduction 6.4%	280.0	26.9	8.8% (2.4%)	-17.0
	Demand reduction 20%	211.1	95.9	31.2% (11.2%)	-8.0
	Demand reduction 20% + Improve mix	194.6	112.4	36.6% (16.6%)	7.6 (98.2)

Scenario Analysis

- Passive demand reduction scenario

Scenario	Composition	GHG			
		MCO2t		Reduction rate (excluding indirect emission)	$/CO2t
		emission	reduction		Reduction Cost (excluding demand re. cost)
Baseline		307.0	-	-	-
Passive	Demand reduction 6.4% + New tech.(Conservative)	272.7	34.3	11.2% (4.8%)	-12.3 (4.6)
	Demand reduction 6.4% + New tech.(Middle)	272.1	34.9	11.4% (5.0%)	-11.9 (14.9)
	Demand reduction 6.4% + New tech.(Progressive)	257.0	50.0	16.3% (9.9%)	6.1 (47.3)
	Demand reduction 6.4% + New tech.(Progressive) + Improve mix (to Target)	205.4	101.6	33.1% (26.7%)	70.2 (132.3)

CO2 constraint

Scenario Analysis

- Active demand reduction scenario

Scenario	Composition	GHG			
		MCO2t		Reduction rate (excluding indirect emission)	$/CO2t
		emission	reduction		Reduction Cost (excluding demand re. cost)
Baseline		307.0	-	-	-
Active	Demand reduction 20% + New tech.(Conservative)	207.6	99.4	32.4% (12.4%)	-5.3 (6.6)
	Demand reduction 20% + New tech.(Middle)	207.1	99.9	32.5% (12.5%)	-4.6 (14.9)
	Demand reduction 20% + New tech.(Progressive)	195.3	111.7	36.4% (16.4%)	1.7 (55.3)
	Demand reduction 20% + New tech.(Progressive) + Improve mix (to Target)	163.6	143.3	46.7% (26.7%)	27.6 (118.9)

CO2 constraint

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Conclusion

- Reduction scenario result
  - Power sector reduction target(26.7%, 2020) was very aggressive.
    - In the most active scenario[Demand reduction 20% + New tech.(Progressive)] , reduction rate is only 16.4%
  - To meet the Target, use the CO2 emission constraint in TIMES model.
    - Variable factors are the mix of Coal and LNG generation
    - Drastic change of mix is required (unrealistic)
  - We need additional tools to meet the target and more progressive efforts.

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