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Development of AIM/End-use Models for Selecting Low Carbon Technology in Indonesia's Iron and Steel Industry

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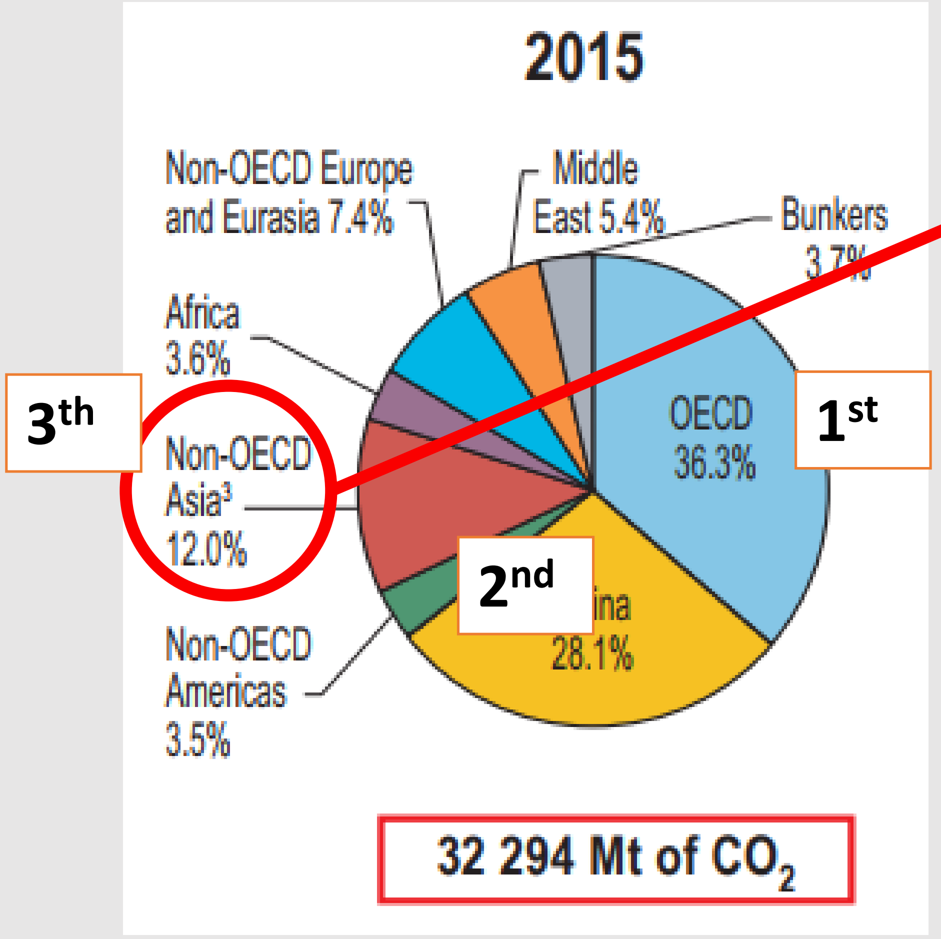
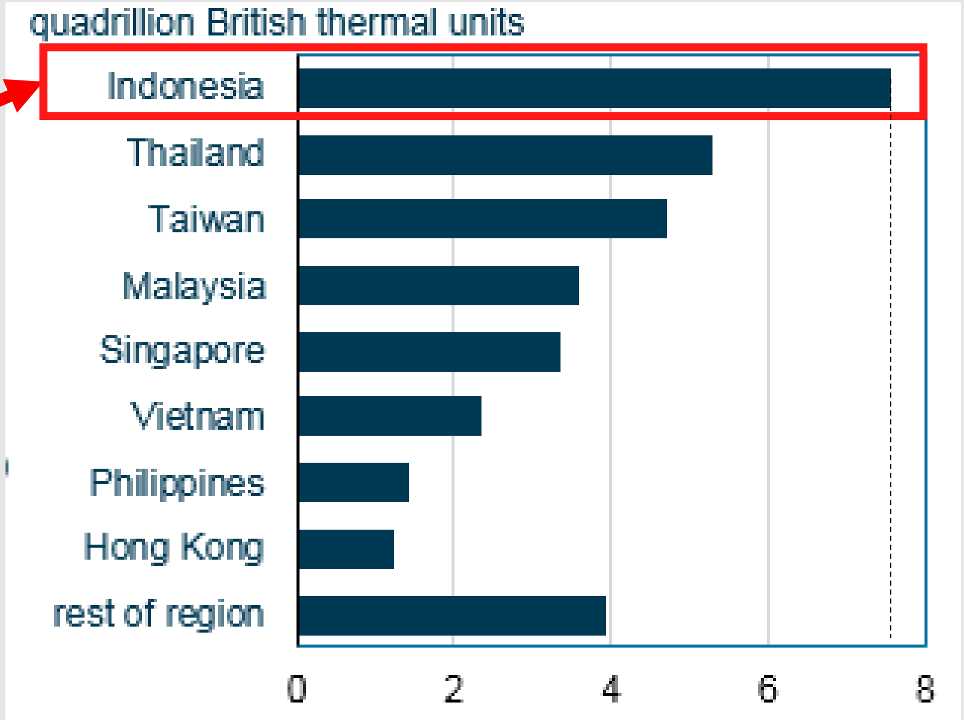
Background



Global CO_2 Emissions

Non-OECD Asia Country Breakout (2015)



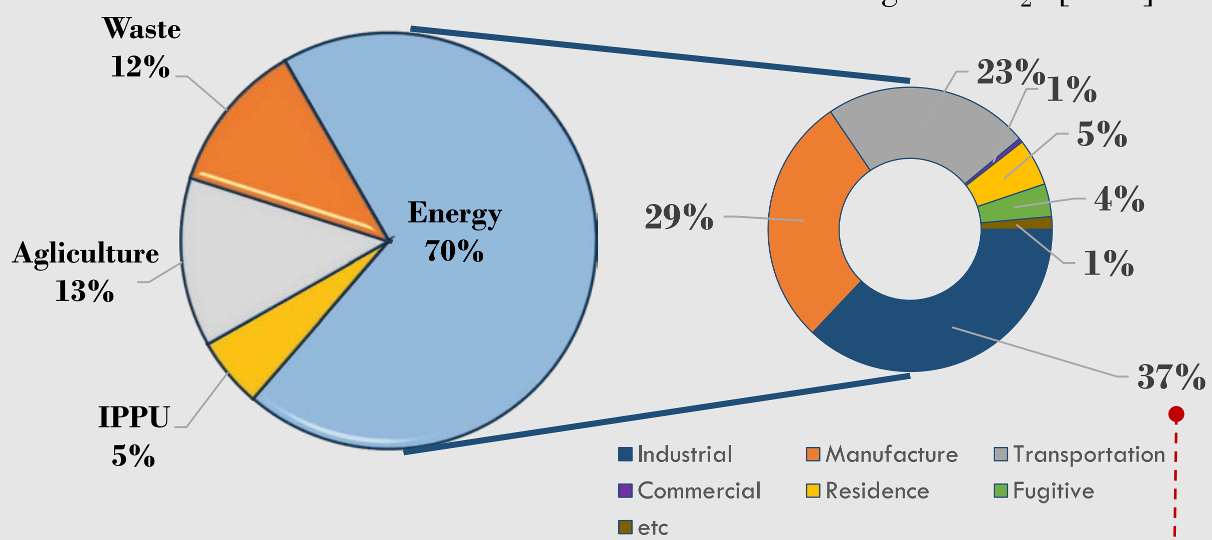
Source U.S. Energy Information Administration. International Energy Statistics and *International Energy Outlook 2017*
Note: OECD is the Organization for Economic Cooperation and Development.

Indonesia's Greenhouse Gases Inventory*

*without LULUCF sector (LUCF and peat fires)

Energy Sector

602.459 Ggram CO_2e [2014]



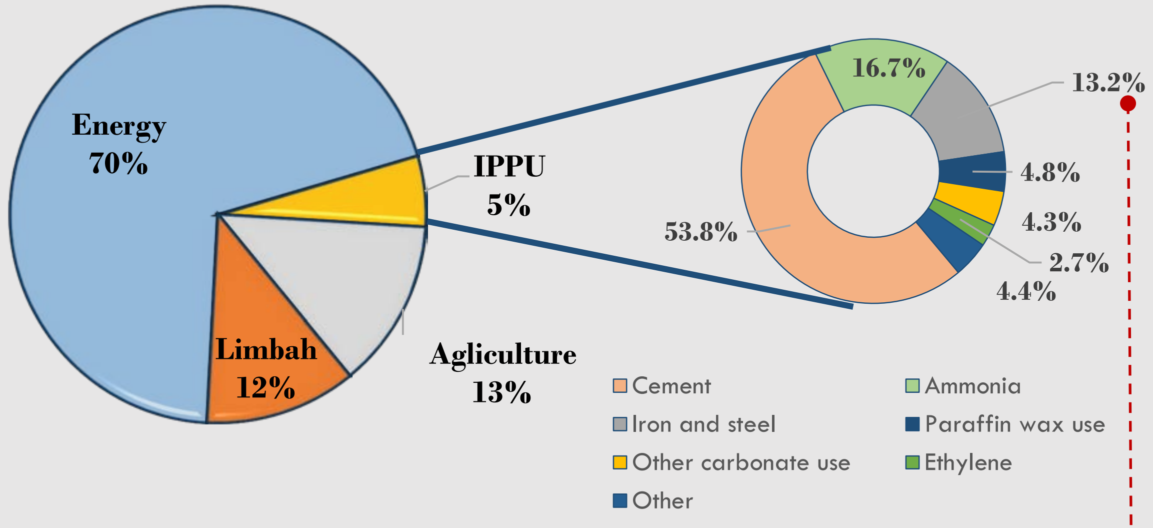
(Indonesia 3[rd] National Communication. 2017)

1st

The industry is **a major sector** of greenhouse gas emission accounting of total emission in the energy sector

IPPU Sector

47.499 Ggram CO_2e [2014]

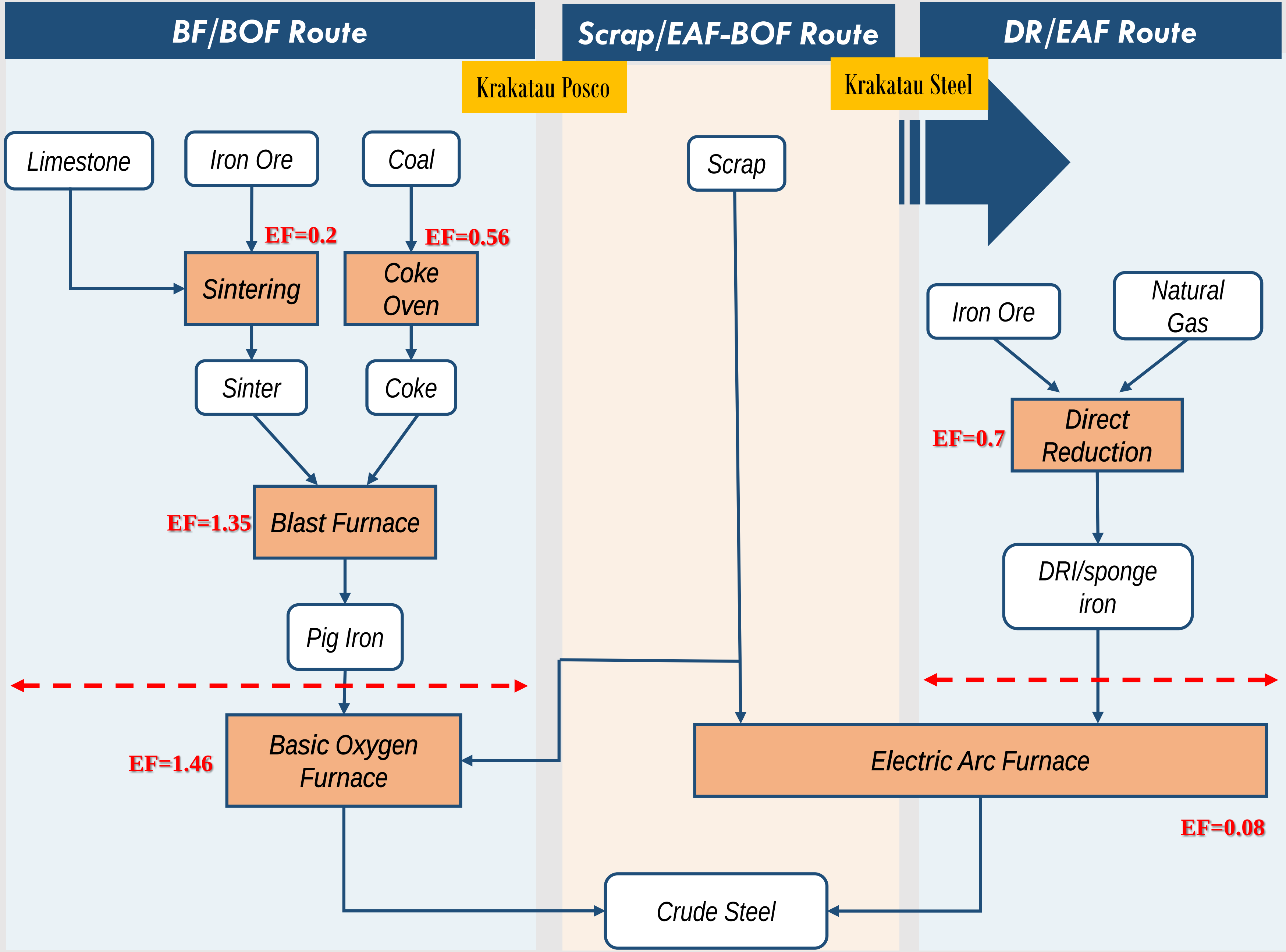


(Indonesia 3[td] National Communication. 2017)

3rd

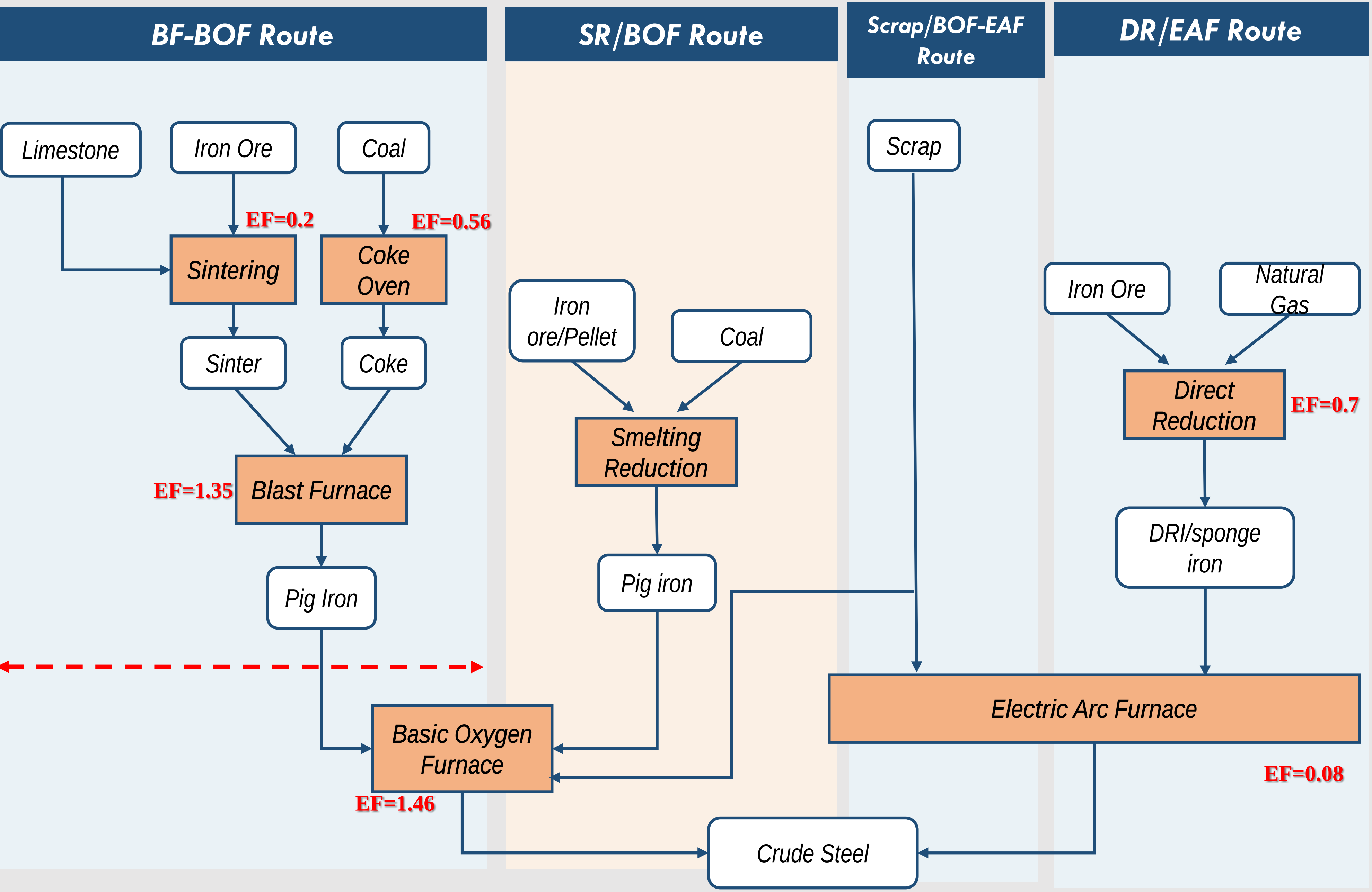
The iron steel industry is one of the largest greenhouse gas emitters in the IPPU sector

Mitigation Options in the Indonesian Iron and Steel industry

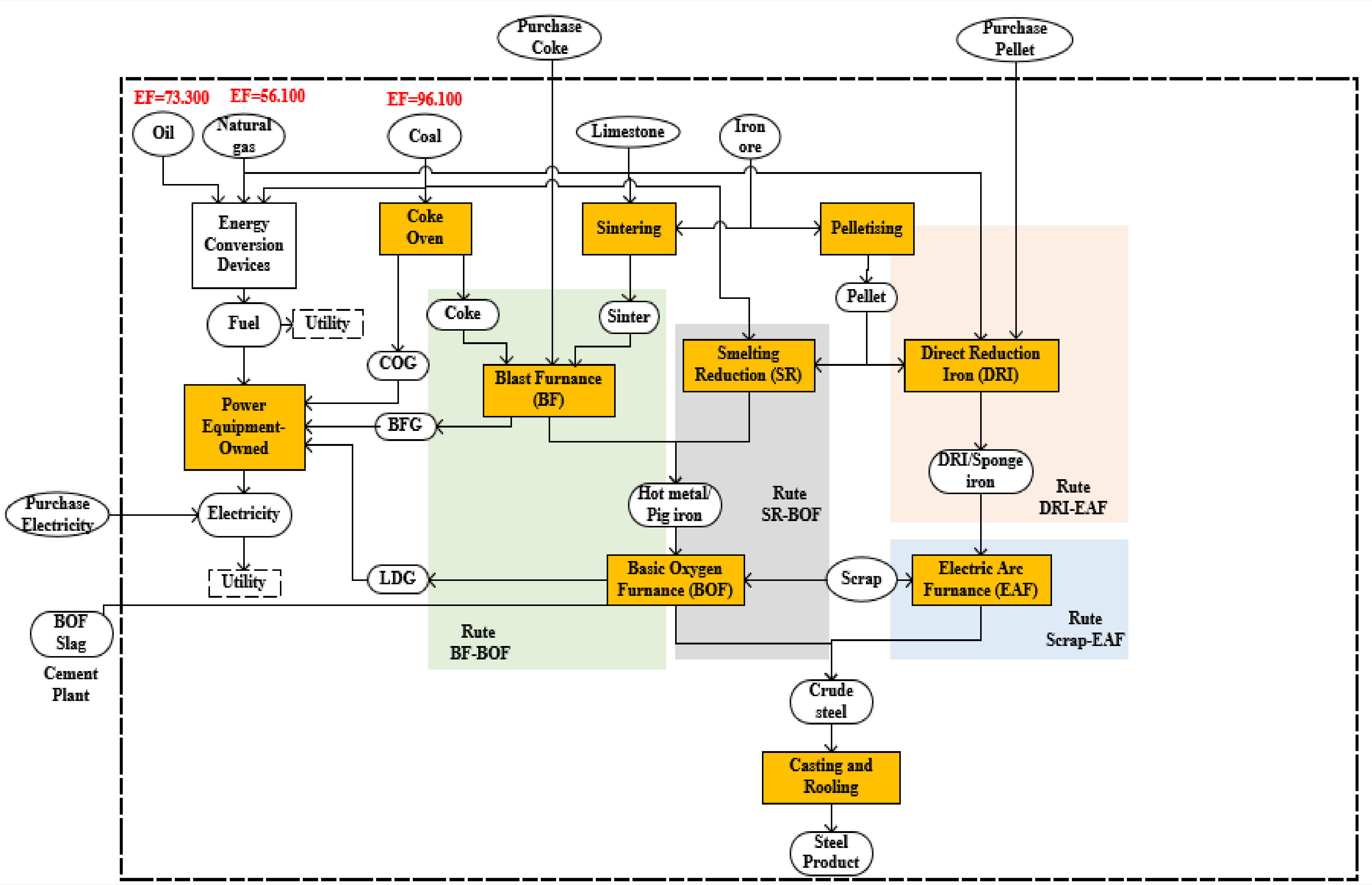


Adjusting the production structure

Mitigation Options in the Indonesian Iron and Steel industry



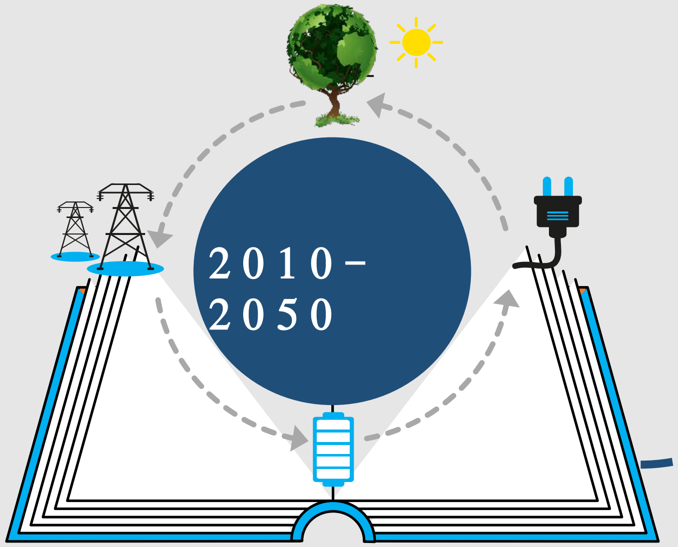
Promoting non-blast furnace technology (smelting reduction)



- Maximized energy efficiency. by promoting low carbon technology
- Substitution of fossil fuels to low emission fuels

Indonesia's iron and steel industry

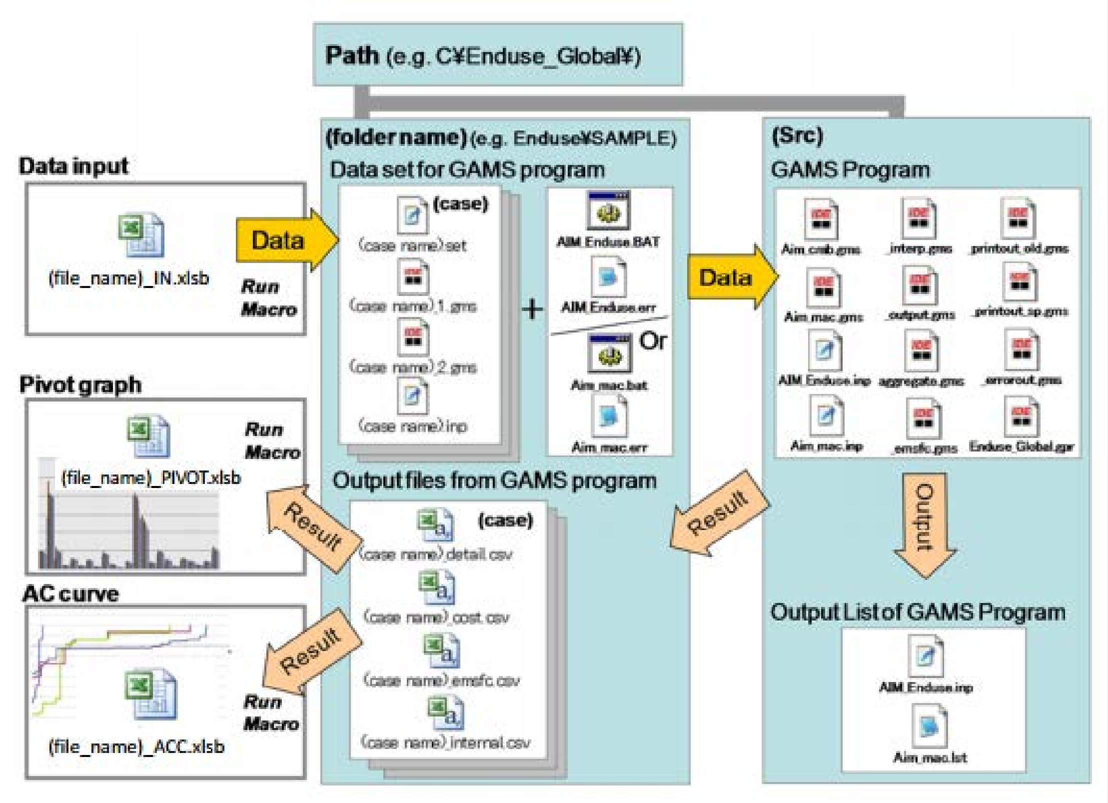
Plays an important role to achieve the target of Indonesia's commitment towards the direction of low-carbon development and future climate resilience.



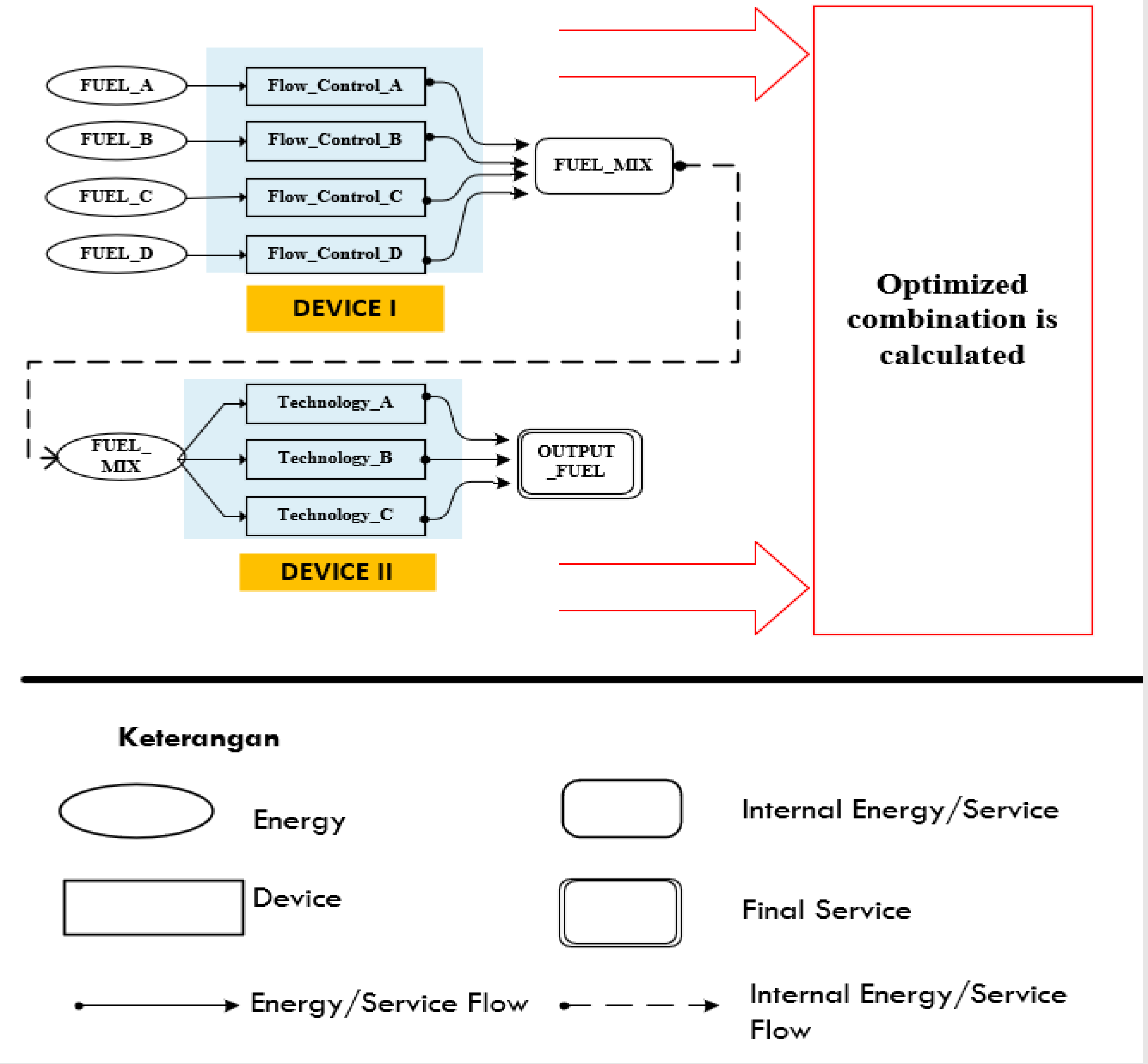
AIM/end-use energy model

(bottom up energy model to analyze the effectiveness of emissions mitigation on potential energy saving and carbon emission reduction)

Conceptual of AIM/end-use model



Systematic workflow of AIM/end-use model



(Manual book AIM/end-use NIES Japan. 2006)

Technology Review

Process	Technology	Fuel Saving (toe)	Electricity Saving (toe)	Capital Cost ($/t product)	OM Cost ($/t product)	Lifetime (Year)
Steel making- Blast Oxygen Furnace	LT-PR of converter gas	0.016480	0	0.26	3.83	15
	flue gas waste heat recovery	0.002150	0	3.74	0.57	10
	Dry gas cleaning system (wet to dry)	0.003344	0	4.53	0	15
	Dry gas cleaning system (wet to dry)	0.000478	0	2.79	0	30
Steelmaking – Electric Arc Furnace	Scrap preheating	0	0.00263	13.19	-16.52	5
	imprroved process control	0	0.00119	27.77	0	5
	flue gas monitoring and control	0	0.00502	14.24	0	5
	UHP transformer	0	0.00167	138.85	-29.73	5
	Foamy slag practice	0	0.00215	75.91	0	5
	Eccentric bottom tapping	0	0.00764	69.42	-28.66	5
	Direct current arc furnace	0	0.00310	0.12	-18.17	5
Hot rolling and casting	Continous casting	0.009315	0	2.77	-8.32	20
	efficient ladle preheating	0.000478	0	2.03	0.00	20
	Integrated casting and rolling (strip casting)	0.006688	0	342.95	-201.79	30
	recuperative burners	0.003583	0	1.79	0.00	10
	process control in hot strip mill	0.006688	0	17.95	0.00	10
	waste heat recovery	0.000955	0	25.24	2.19	15
Cold rolling and finishing	heat recovery on annealing line	0.007165	0.00026	6.38	0.00	10
	Automated monitoring and targeting system	0.000000	0.00516	2.87	0.00	10
	reduced steam use(picking line)	0.002627	0	22.35	0.00	5
	Continous annealing	0.009076	0	46.16	0.00	5
General Technology	cogeneration /CHP	0.009076	0	70.37	0.00	20
	combined cycle power plant (CCPP)	0.012181	0	0.23	0.30	15
Iron making- Non Blast furnace	FINEX			[illegible]		
	Hisarna			259.90		
	MIDREX			113.00		
	Ulcored			282.50		

Structure of AIM/end-use model in the iron steel industry

ENERGY

- Coal
- Natural gas
- Oil
- (Electricity)

TECHNOLOGY

- ~~Automobile~~
- Dryer
- Blast Furnance
- Smelting Reduction
- Direct Reduction
- Basic Oxygen Furnance
- Electric Arc Furnance
- Casting and Rooling
- Pump
- Boiler
- Power Generation

SERVICE

- ~~Transportation~~
- Steel Product

Flow of real world

Flow of simulation

Energy Consumption CO_2 Emission ← **Technology Selection** ← **Energy Service Demand**

Energy Database

- Energy Price
- Energy Type
- Energy Constrain
- Emission factor
- Fuel avability

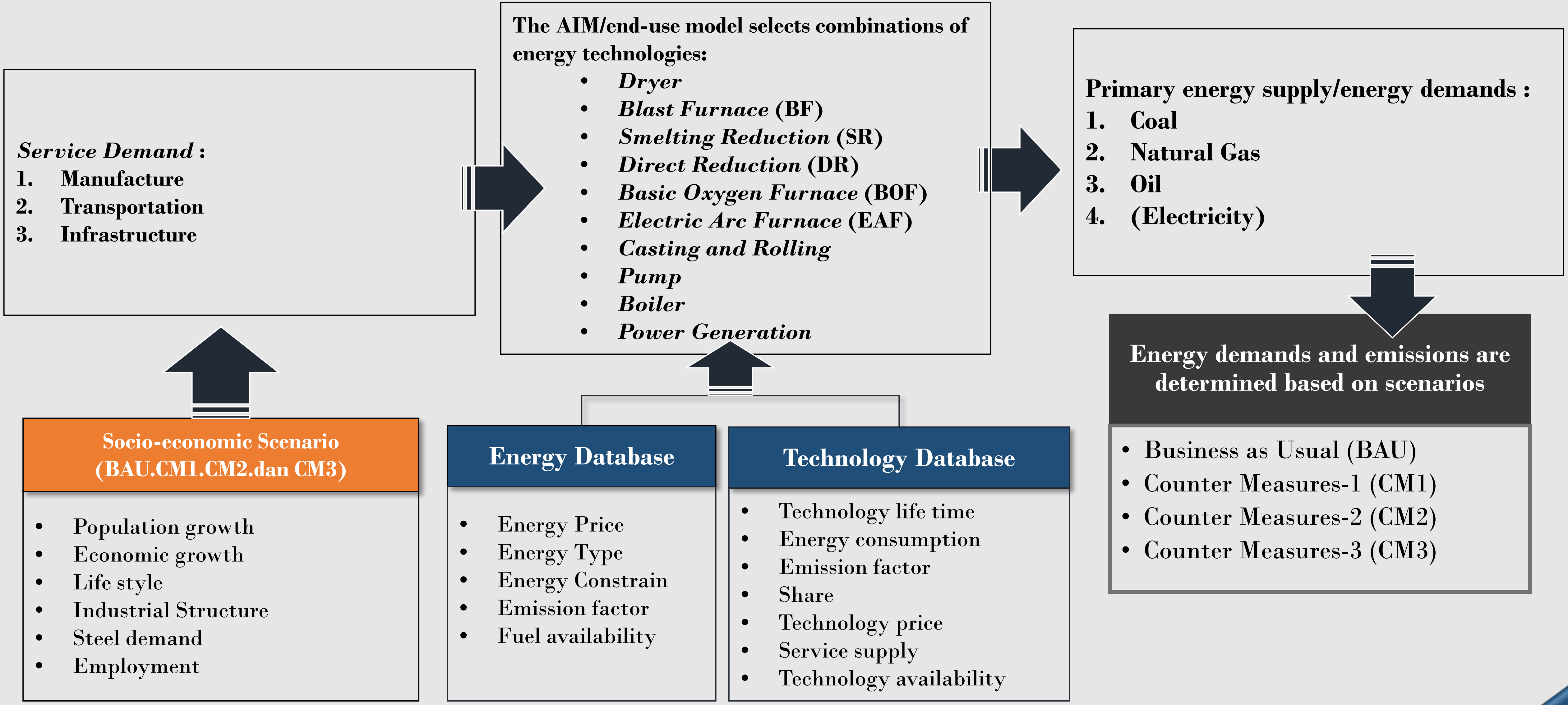
Technology Database

- Technology life time
- Energy consumption
- Emission factor
- Share
- Technology price
- Service supply
- Technology availability

Socio-economic Scenario

- Population growth
- Economic growth
- Life style
- Industrial Structure
- Steel demand
- Employment

(Manual book AIM/enduse NIES Japan. 2006)


Service Demand :
1. Manufacture
2. Transportation
3. Infrastructure
The AIM/end-use model selects combinations of energy technologies:
• Dryer
• Blast Furnace (BF)
• Smelting Reduction (SR)
• Direct Reduction (DR)
• Basic Oxygen Furnace (BOF)
• Electric Arc Furnace (EAF)
• Casting and Rolling
• Pump
• Boiler
• Power Generation
Primary energy supply/energy demands :
1. Coal
2. Natural Gas
3. Oil
4. (Electricity)
Socio-economic Scenario (BAU.CM1.CM2.dan CM3)
• Population growth
• Economic growth
• Life style
• Industrial Structure
• Steel demand
• Employment
Energy Database
• Energy Price
• Energy Type
• Energy Constrain
• Emission factor
• Fuel availability
Technology Database
• Technology life time
• Energy consumption
• Emission factor
• Share
• Technology price
• Service supply
• Technology availability
Energy demands and emissions are determined based on scenarios
• Business as Usual (BAU)
• Counter Measures-1 (CM1)
• Counter Measures-2 (CM2)
• Counter Measures-3 (CM3)

GHG Emission Baseline and Mitigation Scenario

BAU

(Baseline scenario)

- Baseline = which is expected to occur if no mitigation actions

CM 1

(BAU+ Adjusting the production structure)

- Increased proportion scrap use in the steel making (BOF and EAF)

CM 2

(CM1+ promoting low carbon technology)

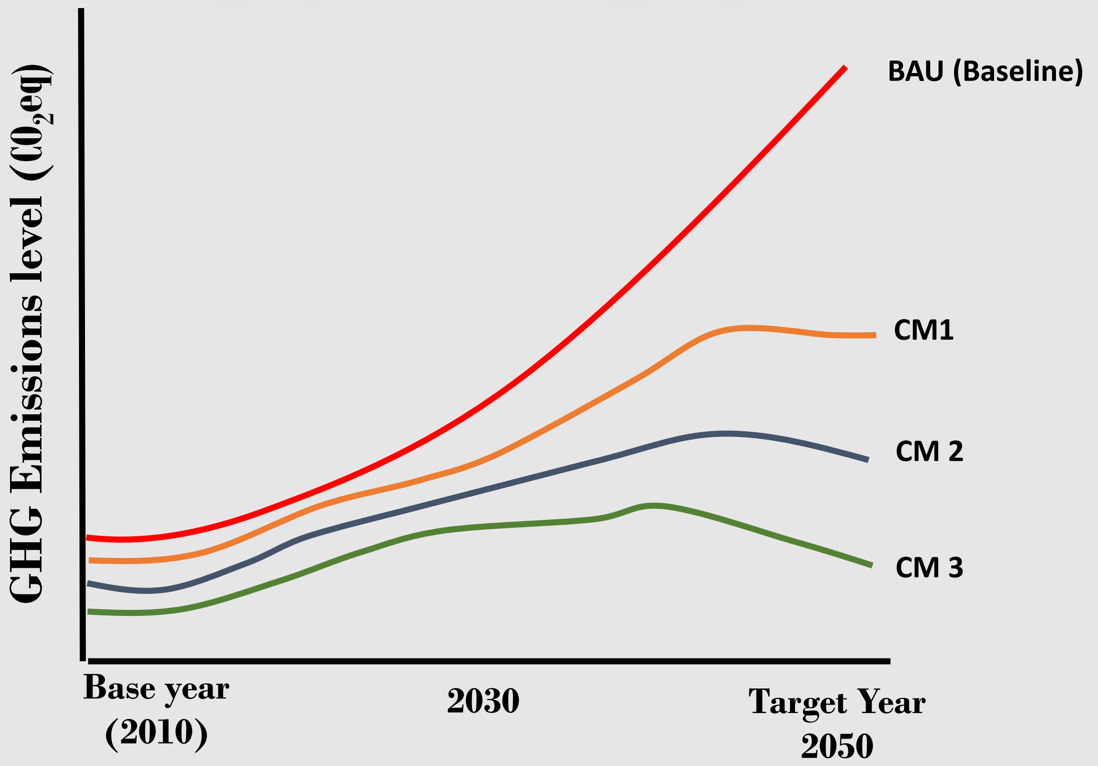
- Maximized energy efficiency
- Promoting low carbon technology and non-blast furnace technology (smelting reduction)

CM 3

(CM2+ Substitution of fossil fuels to low emission fuels)

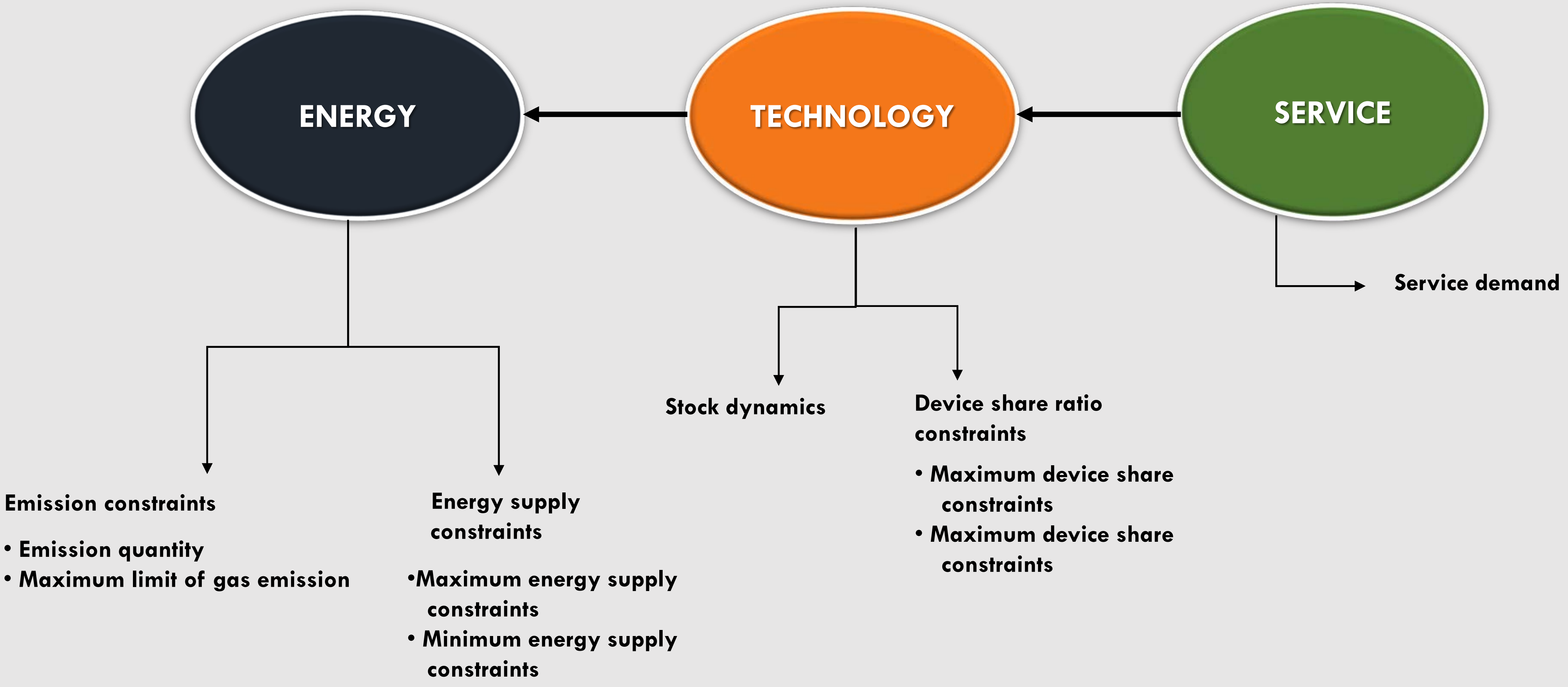
- Switching to low emission fuels
- Increased proportion natural gas

Illustration of GHG emissions level



GHG Reduction = Baseline – Mitigation

Model Constraints



(Source: manual book AIM/enduse NIES Japan. 2006)

Constraints

Additional constraints:
Emission quantity

$$Q(m)=\sum_{l} X(l)\cdot e(l,m)$$

$Q(m)$: *Emission of gas m*
$X(l)$: *Operating quantity of device l*
$e(l,m)$: *Emission of gas m per unit operation device l*

Additional constraints:
Maximum limit of gas emission

$$Q^{m}(m)\leq \hat{Q}(m)$$

$Q^{m}(m)$: *Emission of gas m*
$\hat{Q}(m)$: *Maximum limit on emission of gas m*

Additional constraints:
Service demand

$$D(j)\leq \sum_{l} A(j,l)\cdot X(l)$$

$D(j)$: *Service demand quantity of service type j*
$A(j,l)$: *Output of service j per unit operation of device l*

Additional constraints:
Maximum Energy supply constraints

$$E(k,l)\cdot X(l)\leq \hat{E}^{\max}(k)$$

$E(k,l)$: *Energy use of energy kind k per operating unit of device l*
$\hat{E}^{\max}(k)$: *Maximum supply quantity of energy kind k*
$X(l)$: *Operating quantity of device l*

Additional constraints:
Minimum Energy supply constraints

$$E(k,l)\cdot X(l)\geq \hat{E}^{\min}(k)$$

$E(k,l)$: *Energy use of energy kind k per operating unit of device l*
$\hat{E}^{\min}(k)$: *Minimum supply quantity of energy kind k*
$X(l)$: *Operating quantity of device l*

Additional constraints:
Maximum Device share ratio constraints

$$\theta^{\max}(j,l)\cdot\sum_{l'} A(j,l')\cdot X(l')\geq A(j,l)\cdot X(l)$$

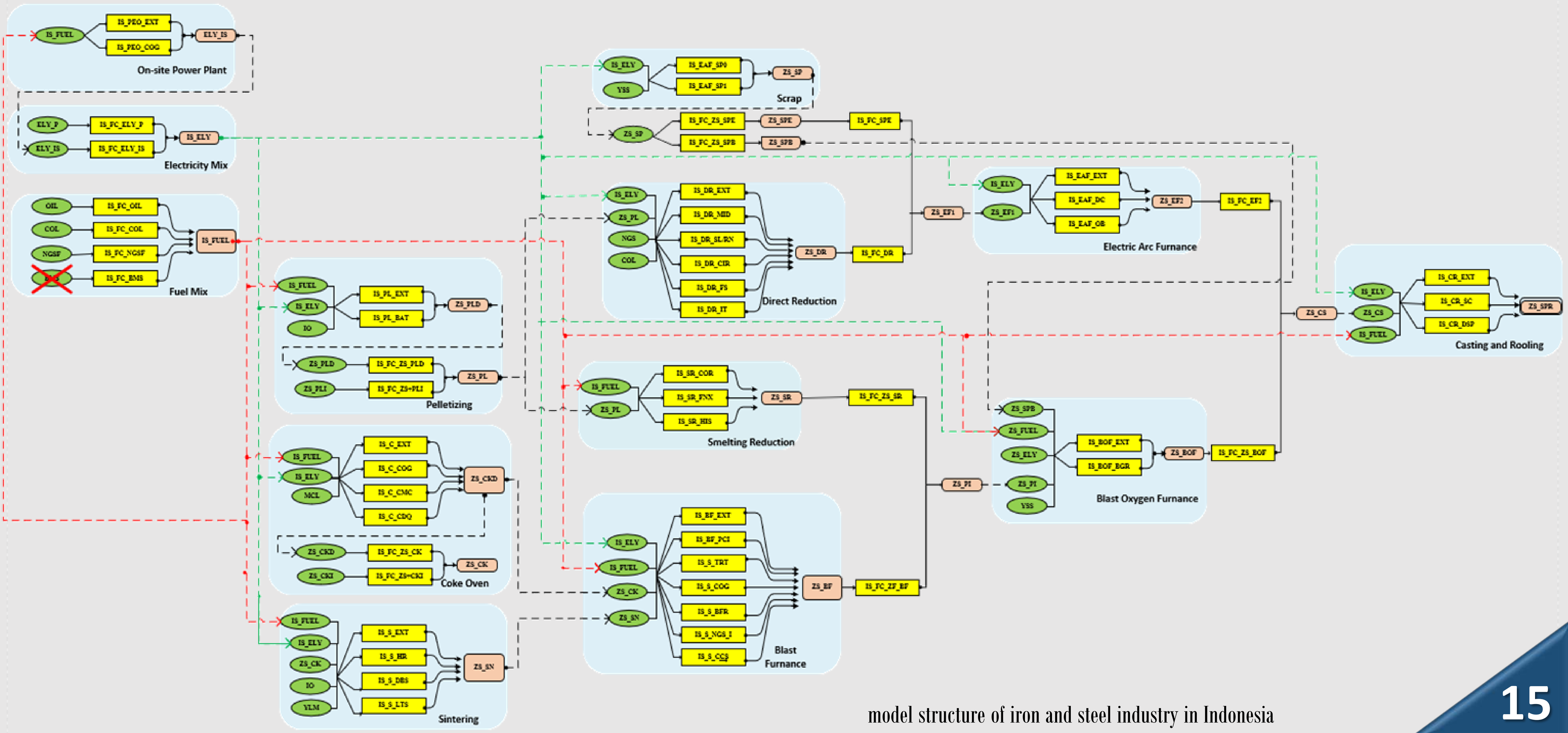
$\theta^{\max}(j,l)$:*Maximum share of device l in service j*
$A(j,l)$: *Service output of service j per operating unit of device l*
$X(l)$: *Operating quantity of device l*

Additional constraints:
Minimum Device share ratio constraints

$$\theta^{\min}(l,j)\cdot\sum_{l'} A(l',j)\cdot X(l')\leq A(l,j)\cdot X(l)$$

$\theta^{\min}(j,l)$:*Minimum share of device l in service j*
$A(j,l)$: *Service output of service j per operating unit of device l*
$X(l)$: *Operating quantity of device l*

Result



model structure of iron and steel industry in Indonesia

THANK YOU...