Technology Choice in Industry

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Modeling and Guiding Technology Choice in Industry

- The Issues
  - Empirical
  - Methodological
- Three Case Studies
- Methodology
- Results

The Issues
Empirical

- Industrial Systems
  - are complex, hierarchical systems
  - require multiple perspectives
  - require aggregation at levels meaningful for decision makers

The Issues
Empirical

- Industrial Systems
  - are complex, hierarchical systems
  - require multiple perspectives
  - require aggregation at levels meaningful for decision makers
- Guiding Investment and Policy Decisions Requires
  - ability to play out rich sets of scenarios
  - interaction with stakeholders in industry and policy

The Issues
Methodological

- Statics vs. Dynamics
- Equilibrium vs. Disequilibrium
- Bottom-up vs. Top-down
- Expert-driven vs. Stakeholder-driven

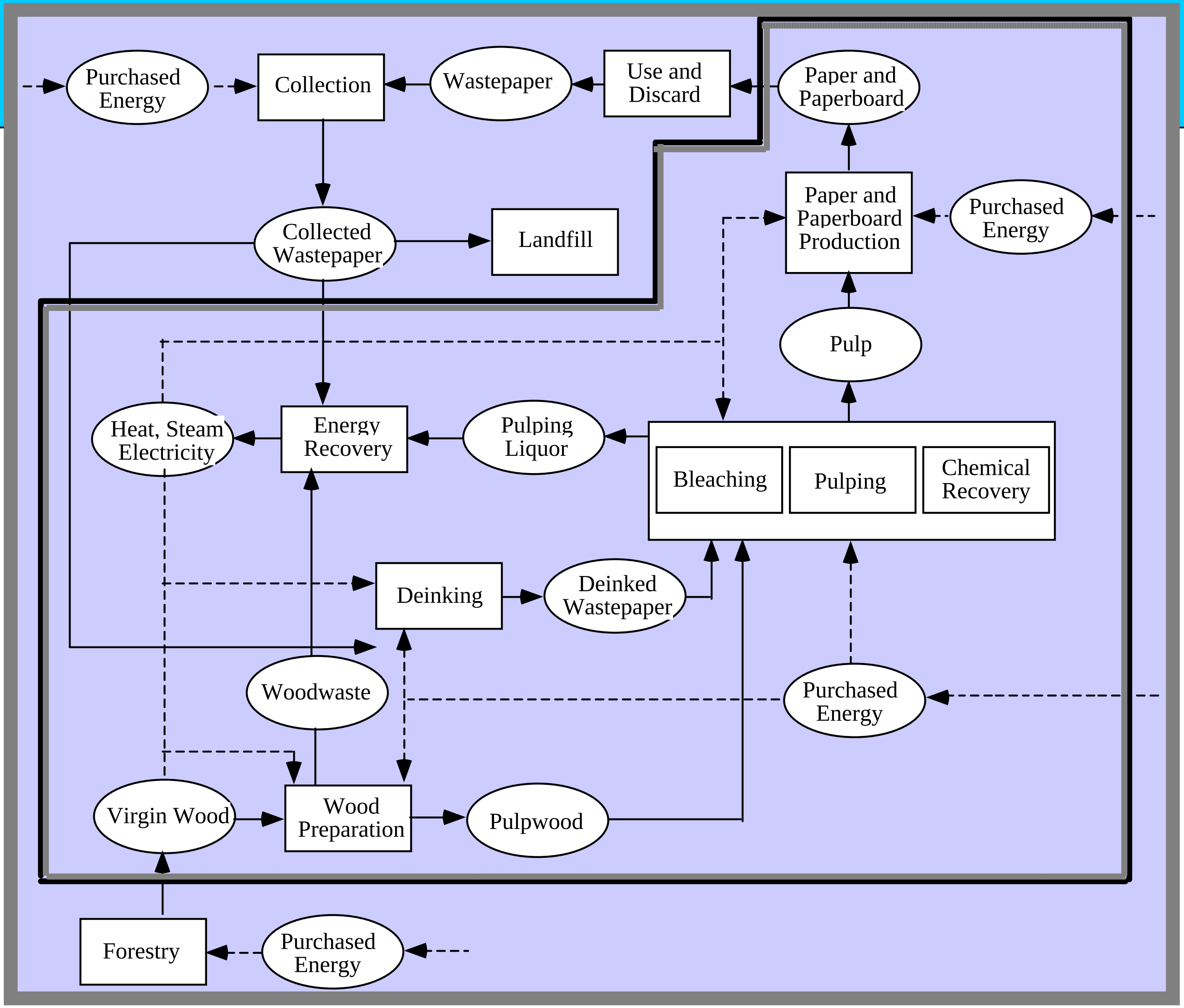
The *Why*, *How* and *What For* of Dynamic Industrial Systems Analysis

- The Issues
- **Three Case Studies**
  - Pulp & Paper
  - Iron & Steel
  - Ethylene
- Methodology
- Results

Three Case Studies
1. US Pulp and Paper

- 2nd most energy intensive US industry
- Accounts for 9% of total US manufacturing carbon dioxide emissions
- High capital intensity and low capital turnover rates
- Over 50% selfgeneration of energy

US Pulp and Paper

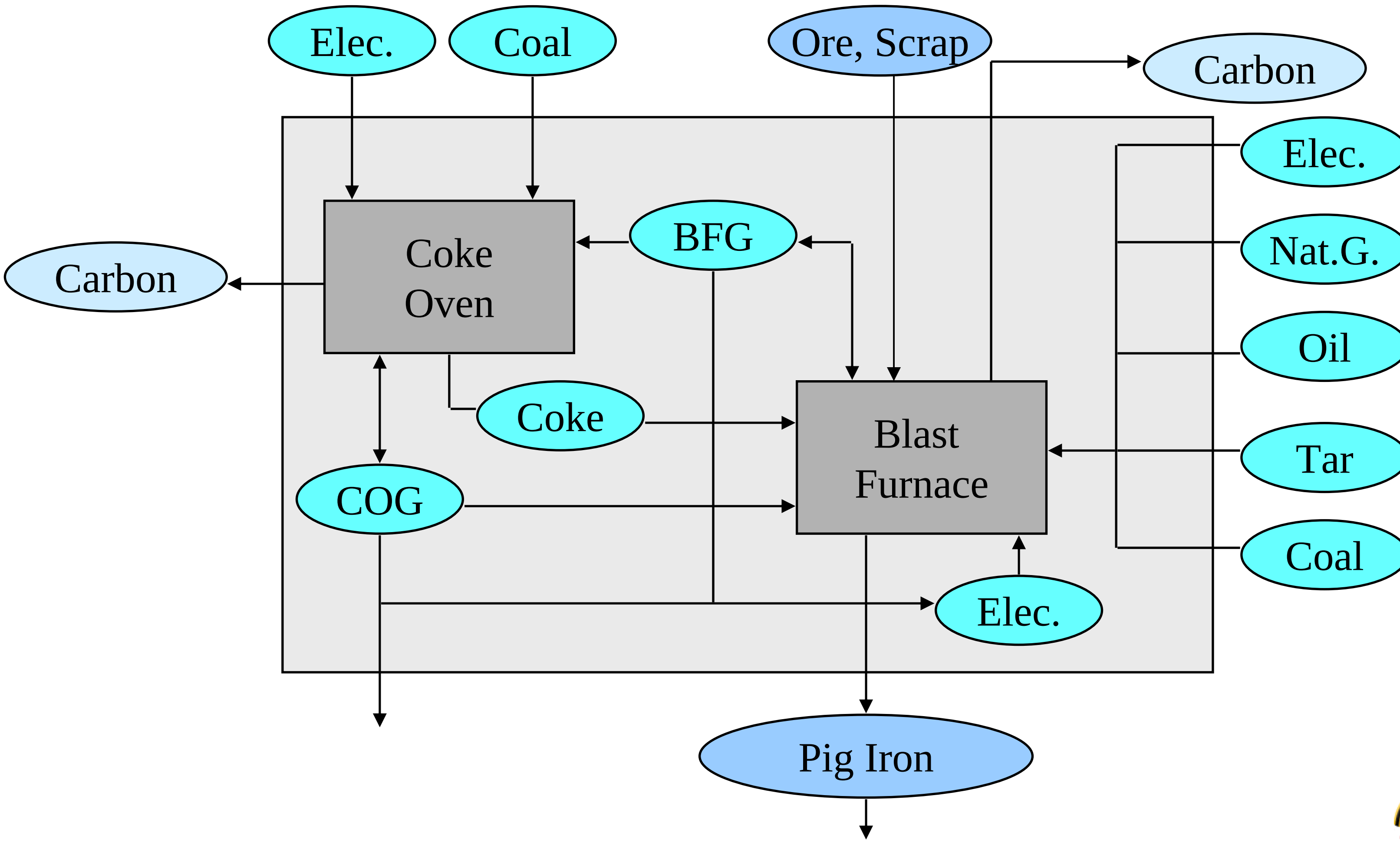


Three Case Studies
2. US Iron and Steel

- 4th most energy-intensive industry in the USA
- 3rd largest steel producer in the world
- High capital intensity and slow capital turnover rates
- Close ties to infrastructure development
- Significant influence on domestic and international policy agendas

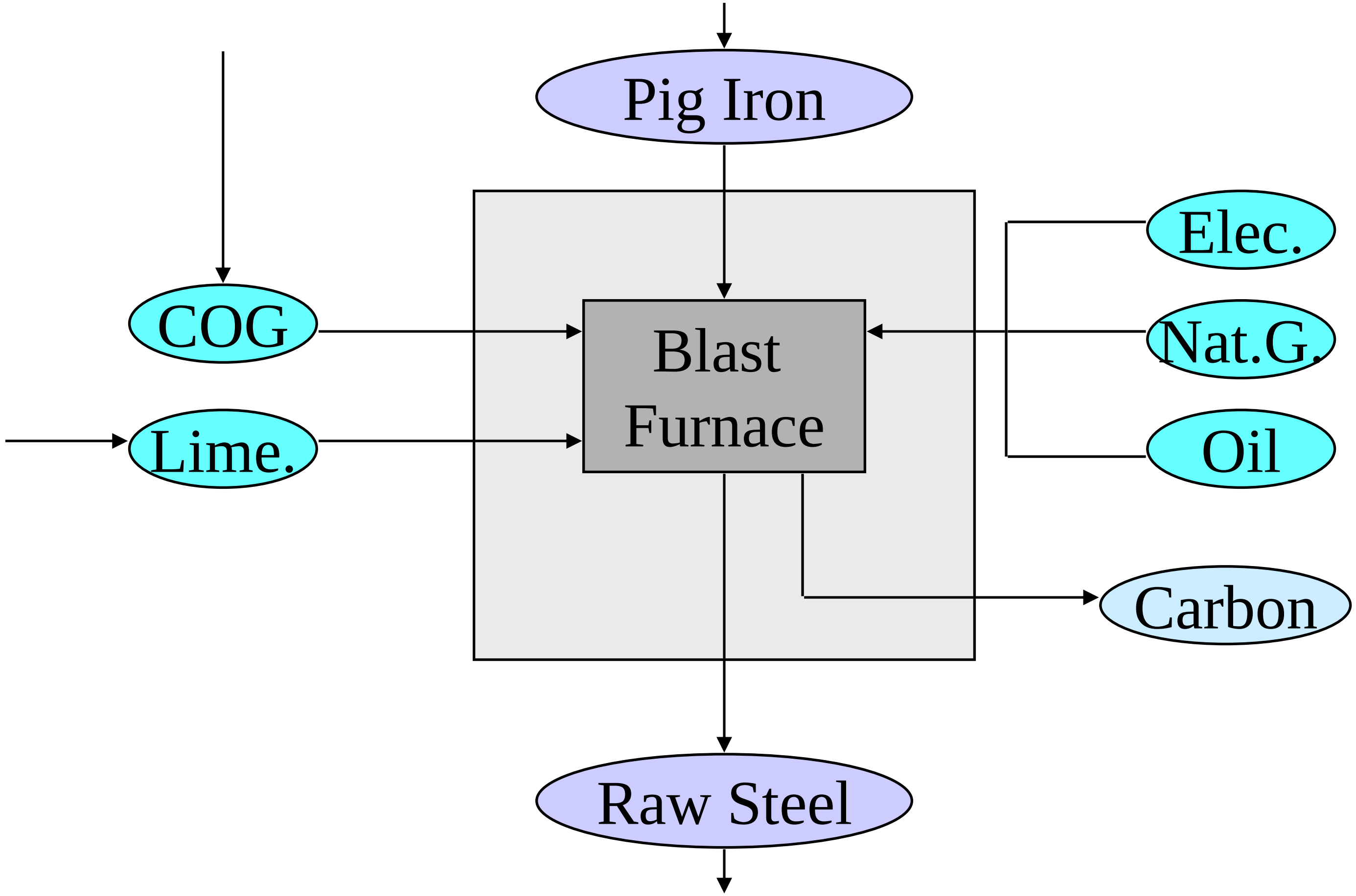
US Iron and Steel

Coke Oven and Blast Furnace Production



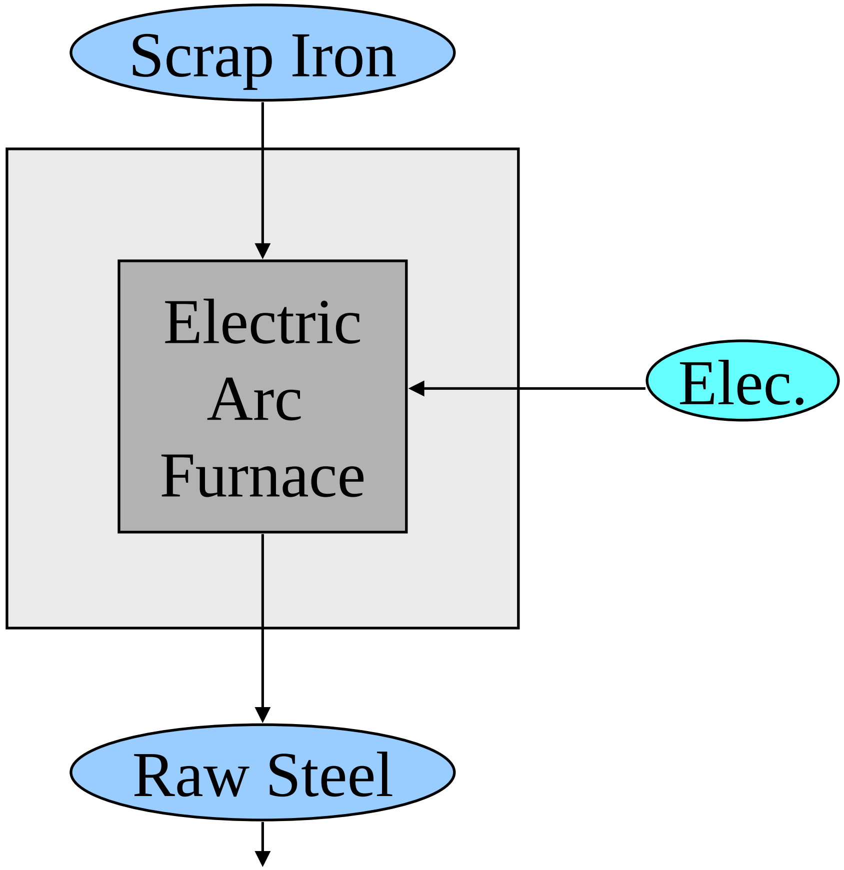
US Iron and Steel

Basic Oxygen Furnace Production



US Iron and Steel

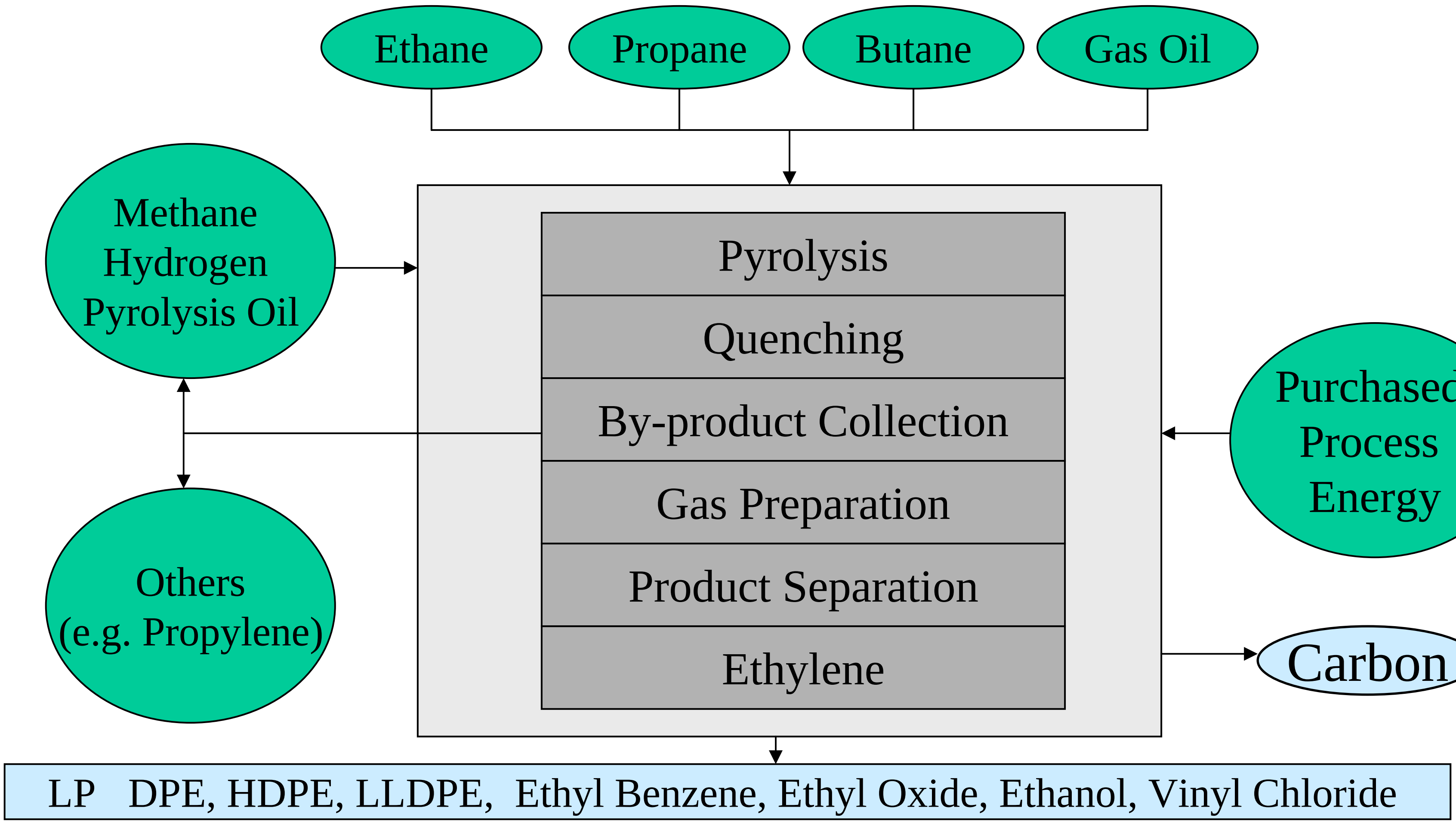
Electric Arc Furnace Production



Three Case Studies
3. US Ethylene Production

- US Chemicals Industry accounts for 25% of manufacturing energy use
- US Ethylene production accounts for 28% of world capacity
- High capital intensity and relatively high capital turnover rates
- Significant use of fuels as feedstock

US Ethylene


Ethane
Propane
Butane
Gas Oil
Methane
Hydrogen
Pyrolysis Oil
Pyrolysis
Quenching
By-product Collection
Gas Preparation
Product Separation
Ethylene
Purchased
Process
Energy
Others
(e.g. Propylene)
Carbon
LP DPE, HDPE, LLDPE, Ethyl Benzene, Ethyl Oxide, Ethanol, Vinyl Chloride

Modeling and Guiding Technology Choice in Industry

- The Issues
- Three Case Studies
- Methodology
  - Engineering Analysis
  - Capital Vintage Analysis
  - Time Series Analysis
  - Dynamic Modeling
  - Stakeholder Involvement
- Results

Engineering Analysis

- Target efficiencies
- Technological limits
- Fixed engineering coefficients

Capital Vintage Analysis

$$K(t) = I(t) + (1-\mu(t))\, K(t-1)$$

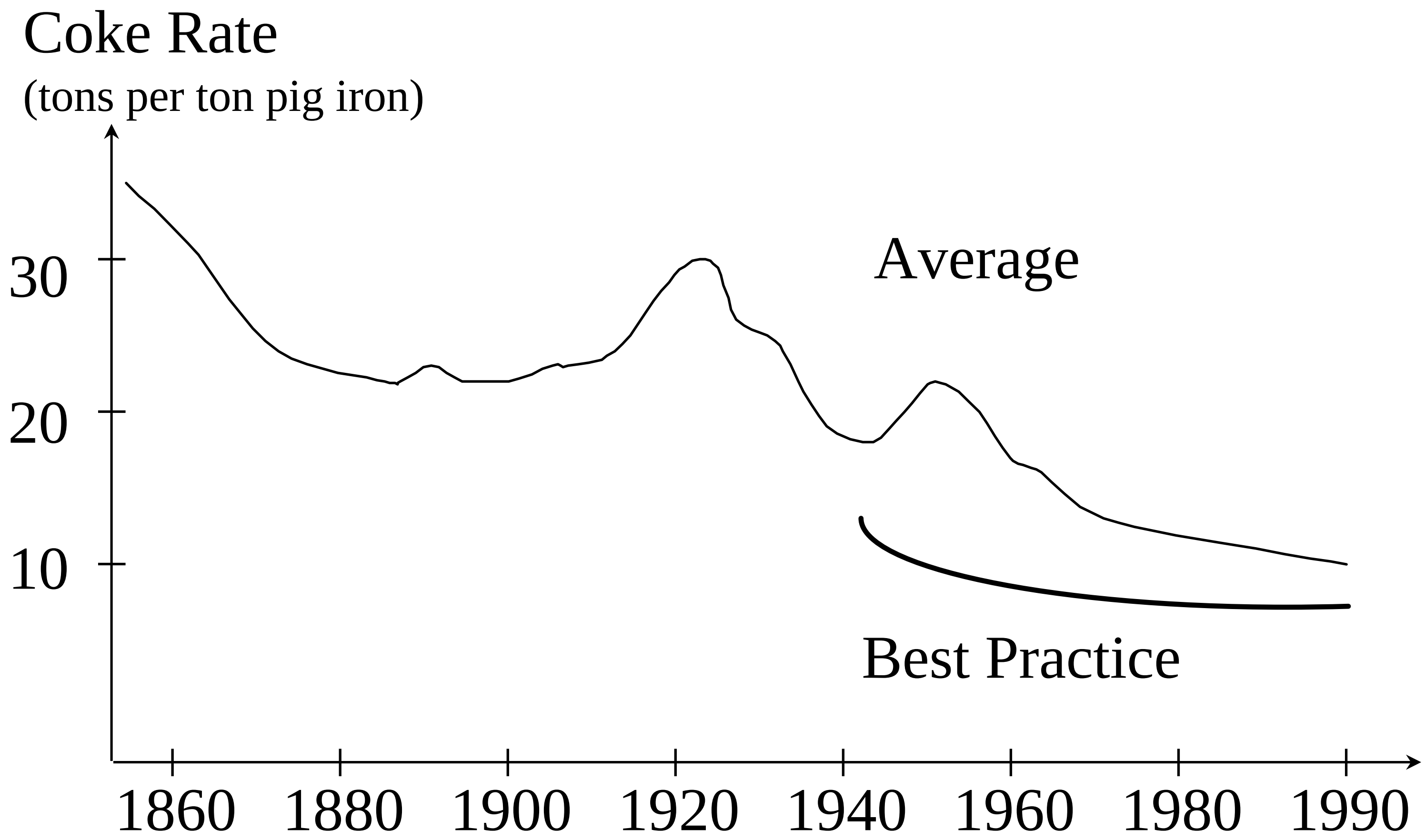
$K(t)$: Capital Stock in t

$I(t)$: Investment in t

$\mu(t)$: Deterioration in t

Vintage Effects

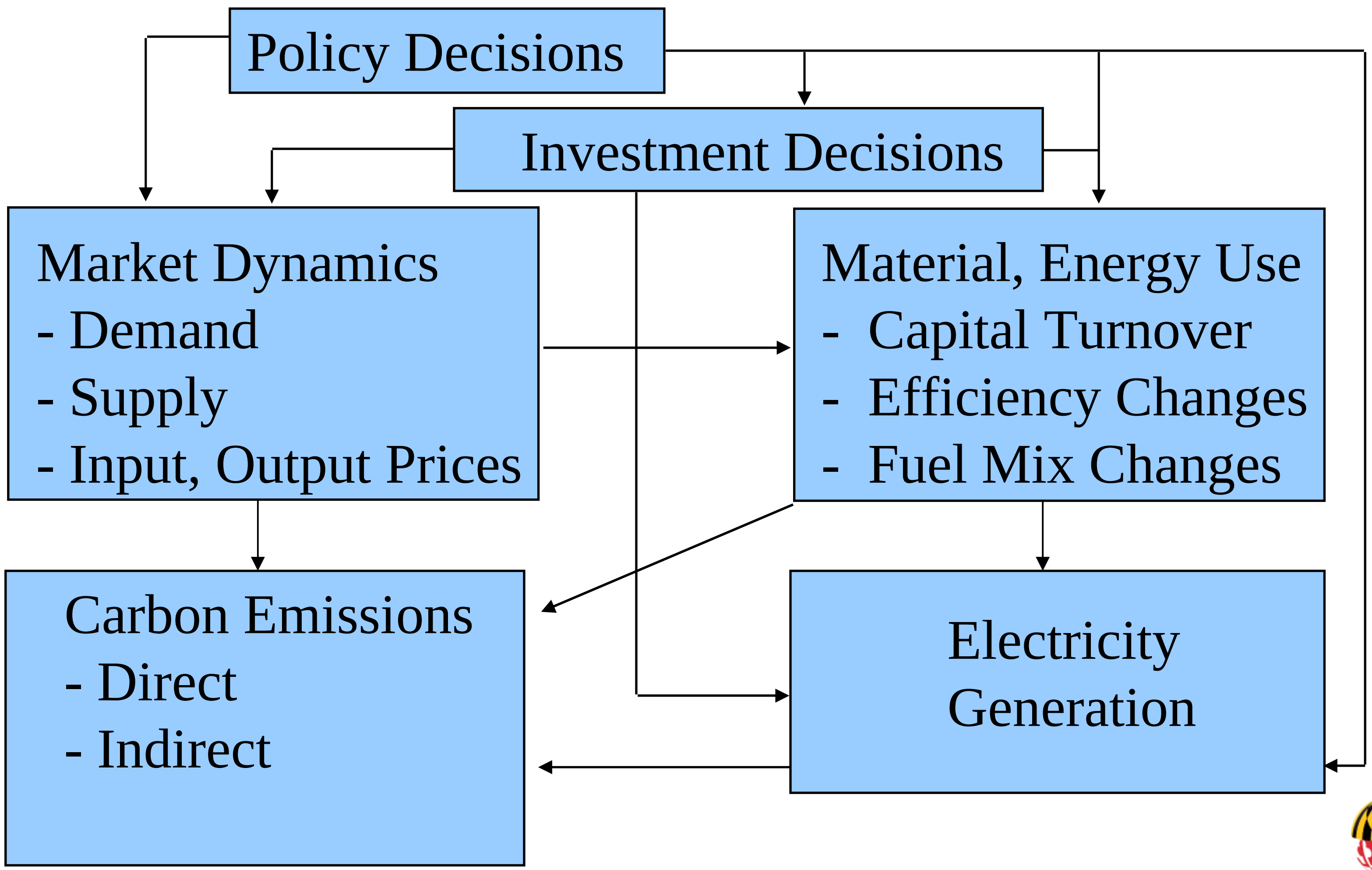
Average and Best Practice Coke Use in Blast Furnaces



Time Series Analysis

- Seemingly unrelated regressions
- Polynomial distributed lags
- Tests for
  - structural breaks
  - heteroscedasticity
  - serial autocorrelation

Dynamic Model



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How good is the model?

- Replication of historic data
- Sensitivity analyses
- Robustness tests
- Dialog with decision makers

Model Operation

Econometric Model Operation

The slider bars are used to change the annual rates of GDP, trade weighted value of the dollar (TWVD), discount rate, rates of expansion of electric arc furnace technology (EAF forecast), tax rates, and population projection. However, changes will only have impact on the model after 1995 because historic data is used to run the model for the years prior to 1995. Values are chosen by moving the slider switch right or left or typing a value in the box below the switch. The slider bar default settings provide a Base scenario that uses regression analysis to forecast future values. After slider settings have been changed, they can be returned to the default settings by clicking on the "U" button that appears. The "?" give a brief description of variable. Any combination of settings can be used in a Model run. For ease of comparison, we recommend changing one variable at a time.

Macro Socioeconomic Sliders	Steel Industry Sliders	Policy Sliders
GDP Forecast Slider: 0.0 – 5.0, value 1.9	EAF Forecast Toggle: 1 – 3, value 2	Early Carbon Implementation Date: 1997 – 2020, value 2000
TWVD Slider: 70 – 120, value 100	Forecast Trend in Steel Price: -0.020 – 0.010, value 0.000	Cost of Carbon: 0 – 100, value 0
Population Forecast: 1 – 3, value 2	Steel Price Elasticity: 0 – 40, value 0	**Scoll down to activate the CAPITAL VINTAGE model.**
Discount rate: 0.0 – 10.0, value 5.0		

To Run Graph of Model | Return to Model Introduction | To LIEF Model and Parameters | To details of econometric model

Capital Vintage Modeling Technique

Embedded within the econometric model is the option to use a captial vintage modeling technique. This technique designates a specific lifetime and energy efficiency to units of produciton capacity. Energy efficiency improvements for a production process thus occur as new capital is installed and old capital retired. However, steel production rates and fuel switching are still estimated through the econometric model.

Prior to navigating to and activiating the capital vintage model the econometric sliders (above) should be set to the desired options.

To Capital Vintage Model and Parameters

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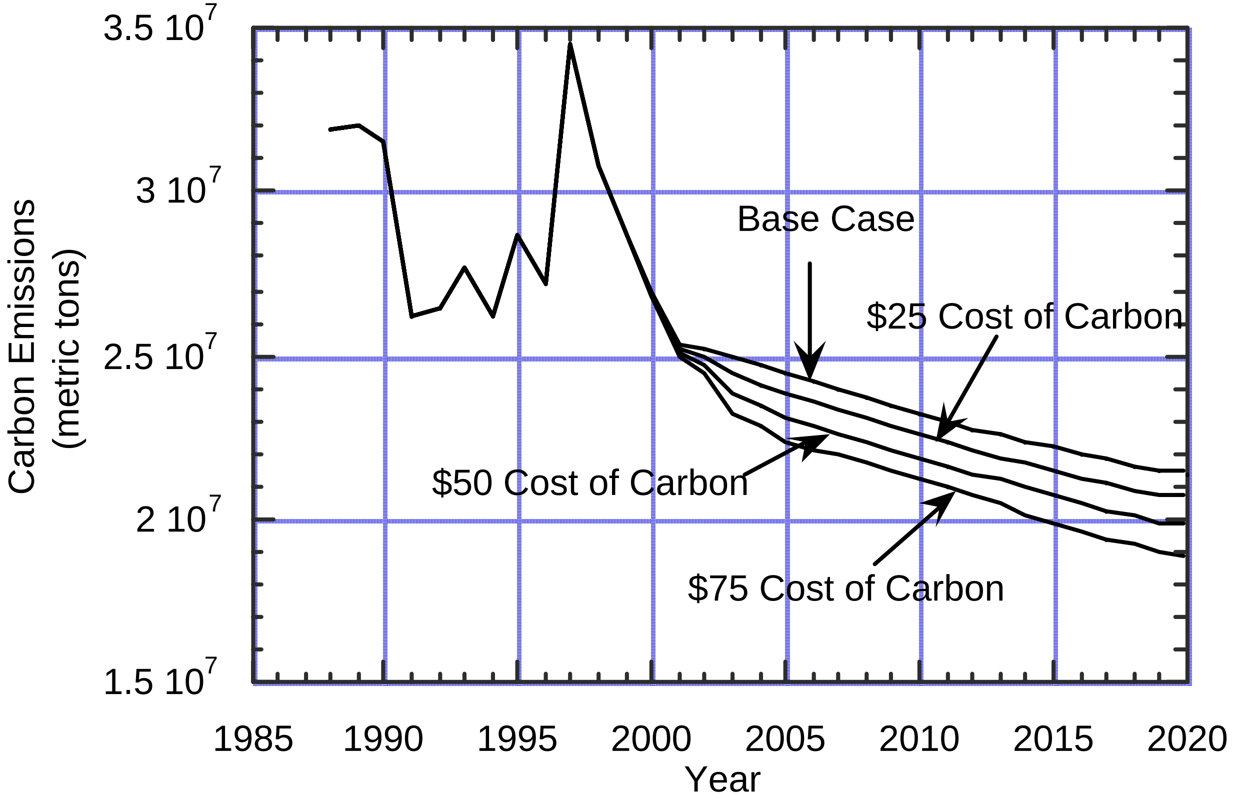
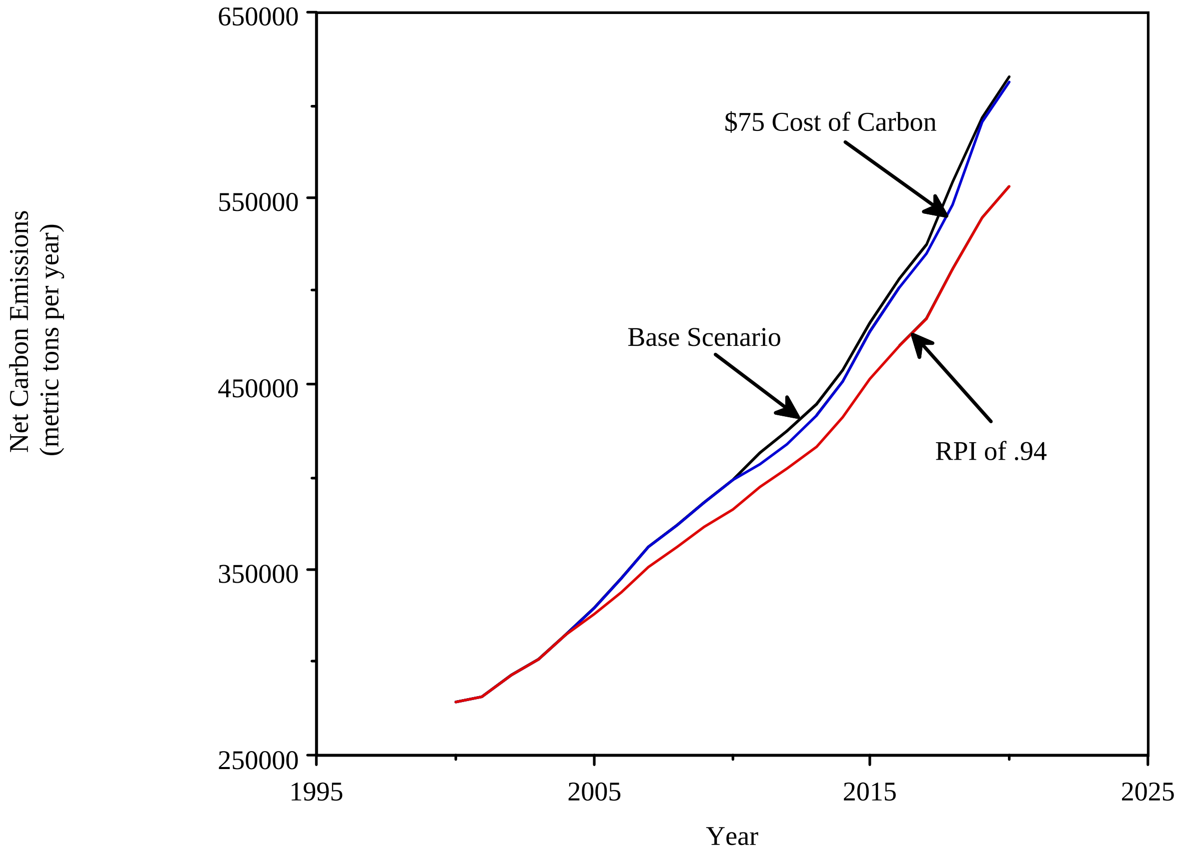
  - Material and Energy Use Dynamics
  - Comparative Analysis
  - Policy Implications

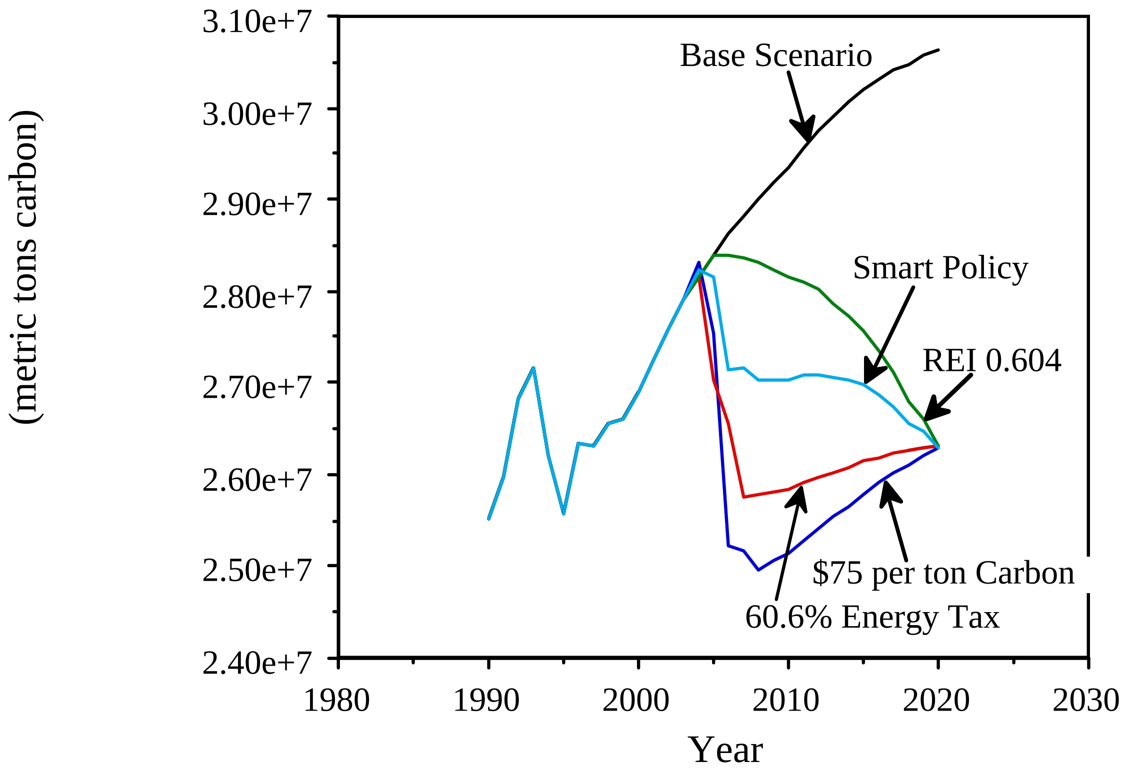
Results: Iron and Steel



Results: Ethylene



Results: Pulp and Paper



Industry Comparison

	Pulp & Paper	Iron & Steel	Ethylene
Base Case Total Production *(% Change 1990 - 2020)*	60	-15	130
$75/ton Carbon Total Production *(% Change 1990 - 2020)*	53	-18	130
Base Case Net Carbon Emissions *(% Change 1990 - 2020)*	-25	-43	245
$75/ton Carbon Net Carbon Emissions *(% Change 1990 - 2020)*	-33	-47	243
Relative Energy Intensity Equivalent to $75/ton Carbon	0.61	0.63	0.94

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Support for Differentiated Policy Intervention

Each industry has

- distinct capital structure dynamics
- specific fuel mix characteristics
- different propensities to respond to policy

→ Uniform policy measures may miss opportunities for significant carbon emissions reductions

For more information...

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