SAGE Industrial Sector Enhancements

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Prepared for the Energy Technology Systems Analysis Program (ETSAP)

June 27-July 1, 2006
Cape Town, South Africa

Issues to be Addressed

- Combined heat and power production and use in the industrial sector.
- Where to model technology cost and efficiency tradeoffs?

Industrial CHP, Original Approach

- Auto CHP, Elec, and Heat are modeled as conversion processes along with public utilities.
- Generation from Public Elec, Heat and CHP and from 'Auto' Elec, Heat and CHP are combined and used to meet electricity demand from industries and other end-users.

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Industrial CHP, Issues

- Auto 'CHP' steam production is not related to the steam needs of specific industries. Electricity available to the grid kept at a constant share of total electricity.
- Steam 'traveled' from one industry to the next and even from the industrial sector to other end-use sectors unless carefully constrained.

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Industrial CHP, New Approach

- Eliminate 'Auto' as a conversion process. All 'Auto' fuel is used directly in specific industries to provide steam and electricity.

  Auto (Fuel) = Auto CHP (Fuel) + Auto Elec (Fuel) + Auto Heat (Fuel)

  Industrial Fuel (Total) = TFC (Fuel) + Auto (Fuel)

- Assume self-generated industrial electricity can be used anywhere in the energy system. Steam stays in the industry where it was produced.

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Industrial CHP, New Approach, Cont. (1)

- 1000 PJ of coal and 1000 PJ of gas in IEA 'Auto' is treated as final industrial consumption:

Industry	Coal	Gas
– Food	150 PJ	300 PJ
– Paper	200 PJ	100 PJ
– Chemicals	200 PJ	300 PJ
– I and S	200 PJ	50 PJ
– N-Ferrous	50 PJ	0 PJ
– Agricult.	0 PJ	100 PJ
– N-M Min	50 PJ	50 PJ
– Other	150 PJ	100 PJ

Industry	Coal	Natural Gas
Food	15%	30%
Paper	20%	10%
Chemicals	20%	30%
Iron and Steel	20%	5%
Non-Ferrous	5%	0%
Agriculture	0%	10%
Non-Metallic Minerals	5%	5%
Other	15%	10%

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Industrial CHP, New Approach, Cont. (2)

- Assign energy sub service shares by industry and fuel
- Steam from boilers tracked separately from cogen **for each industry.**
- Combining tables, for the food industry, cogen, boiler, and process heat use 75 PJ, 45 PJ, and 30 PJ of coal, respectively.

Food Industry **Energy Service Shares**	**Coal**	**Natural Gas**
Cogeneration of Steam and Elec	50%	15%
Boiler (Steam Only)	30%	20%
Process Heat	20%	60%
Electrochemical	0%	0%
Machine Drive	0%	0%
Miscellaneous	0%	5%
Non Energy	0%	0%

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Industrial CHP, New Approach, Cont. (3)

- Other Needed Assumptions
  - Estimates of CHP efficiency.
  - Ratio of electricity to steam output for each industry and fuel combination.
  - Share of self-generated electricity for own use.

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Industrial CHP, New Approach, Cont. (4)

Challenges remain:

- Industry categories are broad.
  - In the chemical industry the value added split between bulk industrial chemicals and pharmaceuticals may change over the forecast and CHP's applicability varies by sub industry category.
- SAGE regions are large.
  - Chemical industry steam produced in Australia cannot be used in New Zealand, and user defined constraints will be necessary.

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Where to Make Investment Decisions?

- Currently, <u>independent</u> decisions are made for each energy sub service level (steam, process heat, machine drive, etc.).

  <u>Example</u> Food industry, 2 sub services, steam and process heat, 2 fuels, coal and oil, time not shown

  1 Food = 100 Steam + 20 Process Heat (***Exogenous***)
  2 Steam Capacity (Coal) = Coal Share * Steam (***Exogenous***)
  3 Investment Choice (Coal) = F (Cost of Steam from Coal Boiler 1, Cost of from Steam from Coal Boiler 2, etc.) (***Endogenous***)

- Results may not reflect capacity found in the 'real world.' For forecasting this is a big problem.

  <u>Example</u> If electricity prices are high and coal prices are low then the highest efficiency motor capacity may be added at the same time the lowest efficiency boilers are chosen.

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Where to Make Investment Decisions? Preliminary Ideas (1)

- Eliminate coal boilers that vary in efficiency from the database.
- Add technologies that vary the combinations of sub services [steam, process heat, etc.] required.
  - Base efficiencies for each industry, Tech Base, are available at ZERO investment cost
  - More efficient combinations are available at incremental investment cost.
    - Technologies are defined within a feasible range for each sub service.

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Where to Make Investment Decisions? Preliminary Ideas (2)

- Possible approach for the incremental cost of energy efficiency
  - If Tech 2 has a higher cost than Tech 1, then:
    - Tech 2(steam) <= Tech 1(steam) AND
    - Tech 2(process heat) <= Tech 1(process heat) AND
    - Etc.
  - Define a maximum efficiency technology, Tech Max, as the maximum efficiency feasible for each sub service
    - How much more does Tech Max cost than Tech Base (exogenous)?
    - What is the cost of achieving the first 10-percent, …the last 10-percent for each sub service jointly? What is the shape of a technology efficiency supply curve?

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Where to Make Investment Decisions? Preliminary Ideas (3)

Technology	Steam	Process Heat	Incremental Investment Cost
Tech Base	100	20	0
Tech 1	95	19	50
Tech 2	90	18	100
Tech 3	85	17	225
Tech Max	70	15	1000

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Where to Make Investment Decisions? Preliminary Ideas (4)

- Joint decisions are made for each energy sub service (steam, process heat, machine drive, etc.).

Example TSC is the reduced cost of providing all energy services required per unit of food output

1 Investment Choice (Food) = F{TSC(Tech Base), TSC(Tech 1)…TSC(Tech Max)} (***Endogenous***)

2 Steam (Coal) = Coal Share * Steam

3 Process Heat (Coal) = Coal Share * Process Heat (***Exogenous***)

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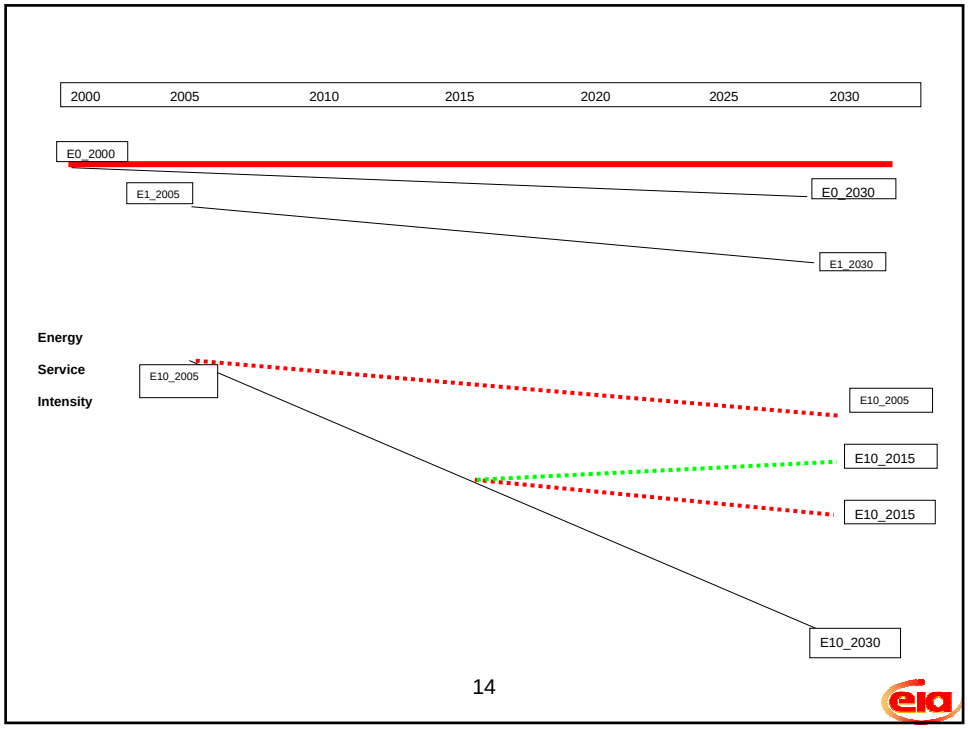
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