USAID SEE Regional Energy Demand Planning Initiative

Overview of SEE-REDP Approach and Program of Work

USAID/Hellenic Aid Cooperative Energy Program
Kick-off Meeting

Athens, Greece
May 19-20, 2008
[Presented by Gary Goldstein]

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Presentation Outline

- SEE-REDP Approach
- Integrated Energy Model Development Components
  - Energy Balance
  - Calibration and Reference
  - Scenario Development
- Overview of the Modeling Tools
- Accomplishments

SEE-REDP Guiding Principles

- Establishment of a network of regional energy experts and policy advisors
- Draw on previous undertakings and share other SEE country experiences and information
- Adopt a common philosophy and “toolbox” for organizing the energy demand planning process
- Compliment other initiatives in the region

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SEE-REDP Components of Energy System Planning

- Depiction of the current energy system, with emphasis on appropriate demand sector detail
- Final energy (fuel) delivered in the base (1st) year, according to the national energy balance
- Demographic and Economic Drivers, and their relationship to future demand for energy services (useful energy)
- Technology and policy options to influence the future demand for final energy, and perhaps the level of useful energy demand
- A modeling framework conducive to enabling the evaluation of alternative futures

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SEE-REDP Proposed Approach

- Establish a consistent representation of a "typical" SEE energy system
- Adopt a common approach to naming the components of each SEE energy system
- Employ "smart" Excel workbooks for gathering data describing the current energy system
- Establish a common characterization of future technologies, adaptable for individual country situations
- Adopt a proven framework able to examine the role of technologies and associated policies in shaping the evolution of the energy system over time, both for individual countries and the region

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Characteristics of a Reference Energy System (RES)

- Network representation depicting the flow of commodities through an energy system
  - Links are commodities and demands
  - Interconnections are supply, transformation or consumption processes
- Network topology relies on either
  - Changing commodity names at each node (process oriented)
  - Explicitly identify each link entering/leaving every node (flow oriented)
- Ensures “conservation of energy” throughout the network

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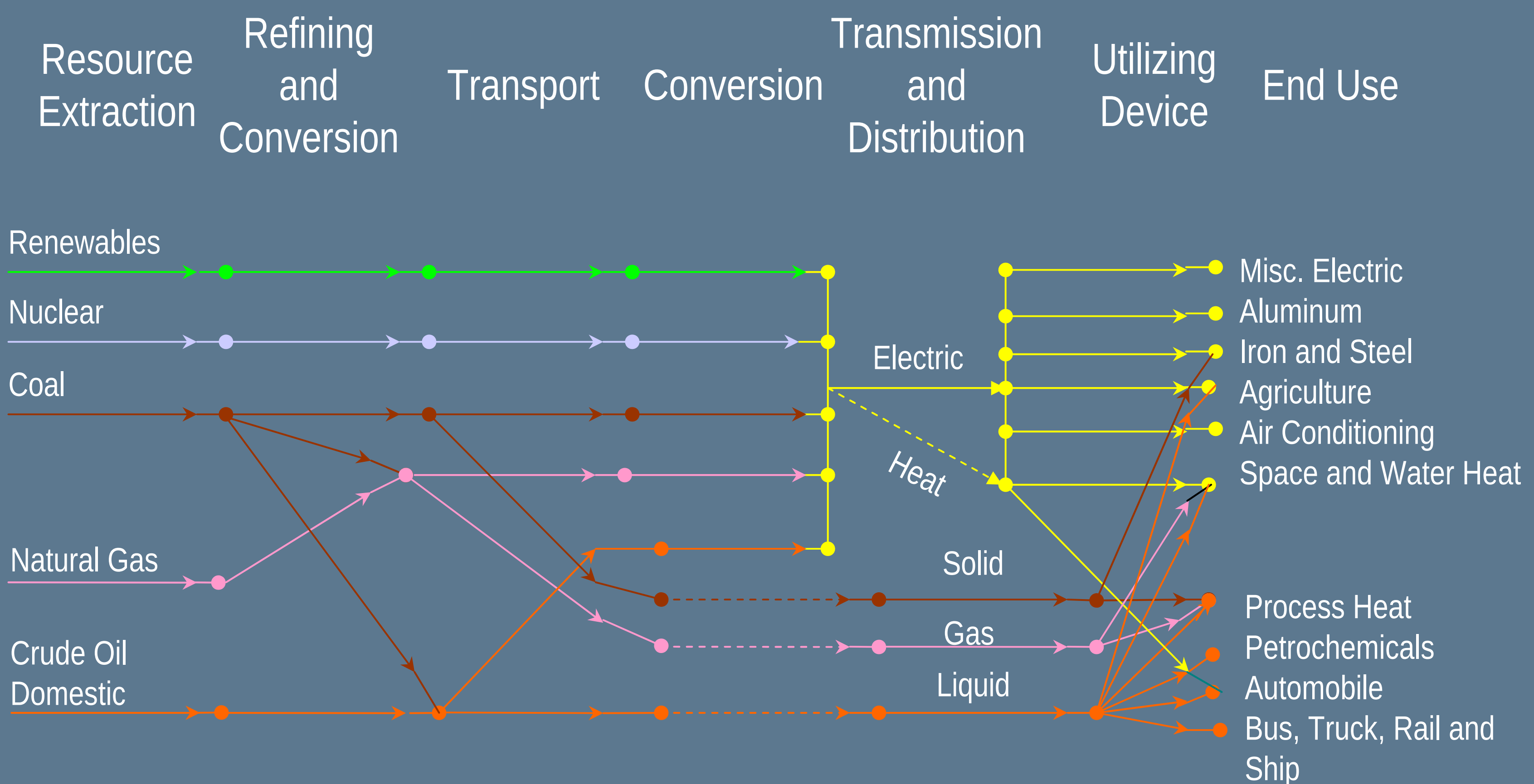
Simplified Reference Energy System



Reference Energy System Components

MARKAL finds the least-cost evolution of the energy system utilizing available resources and technologies to meet the energy service demands, subject to physical limitations, policies and market constraints imposed on the system

PRIMARY ENERGY SUPPLY → *(PRIMARY ENERGY)* → **CONVERSION TECHNOLOGIES** → *(FINAL ENERGY)* → **END-USE TECHNOLOGIES** → *(USEFUL ENERGY)* → **DEMAND FOR ENERGY SERVICE**

PRIMARY ENERGY SUPPLY

Renewables, e.g.
- *Biomass*
- *Hydro*
- *Solar*
- *Wind*

Mining, e.g.
- *Crude oil*
- *Natural gas*
- *Coal*

Imports, e.g.
- *Crude oil*
- *Oil products*

Exports, e.g.
- *Oil products*
- *Coal*

Stock changes

CONVERSION TECHNOLOGIES

Fuel Processing Plants, e.g.
- *Oil refineries*
- *Hydrogen prod.*
- *Ethanol prod.*

Power Plants, e.g.
- *Conventional fossil fueled*
- *IGCC*
- *Solar*
- *Wind*
- *Nuclear*
- *CCGT*
- *Fuel cells*
- *Combined heat and power*

END-USE TECHNOLOGIES

Industry, e.g.
- *Steam boilers*
- *Machinery*

Services, e.g.
- *Air conditioners*
- *Light bulbs*

Households, e.g.
- *Space heaters*
- *Refrigerators*

Agriculture, e.g.
- *Irrigation pumps*

Transport, e.g.
- *Gasoline car*
- *Fuel cell bus*

DEMAND FOR ENERGY SERVICE

Industry, e.g.
- *Process steam*
- *Motive power*

Services, e.g.
- *Cooling*
- *Lighting*

Households, e.g.
- *Space heat*
- *Refrigeration*

Agriculture, e.g.
- *Water supply*

Transport, e.g.
- *Person-km*

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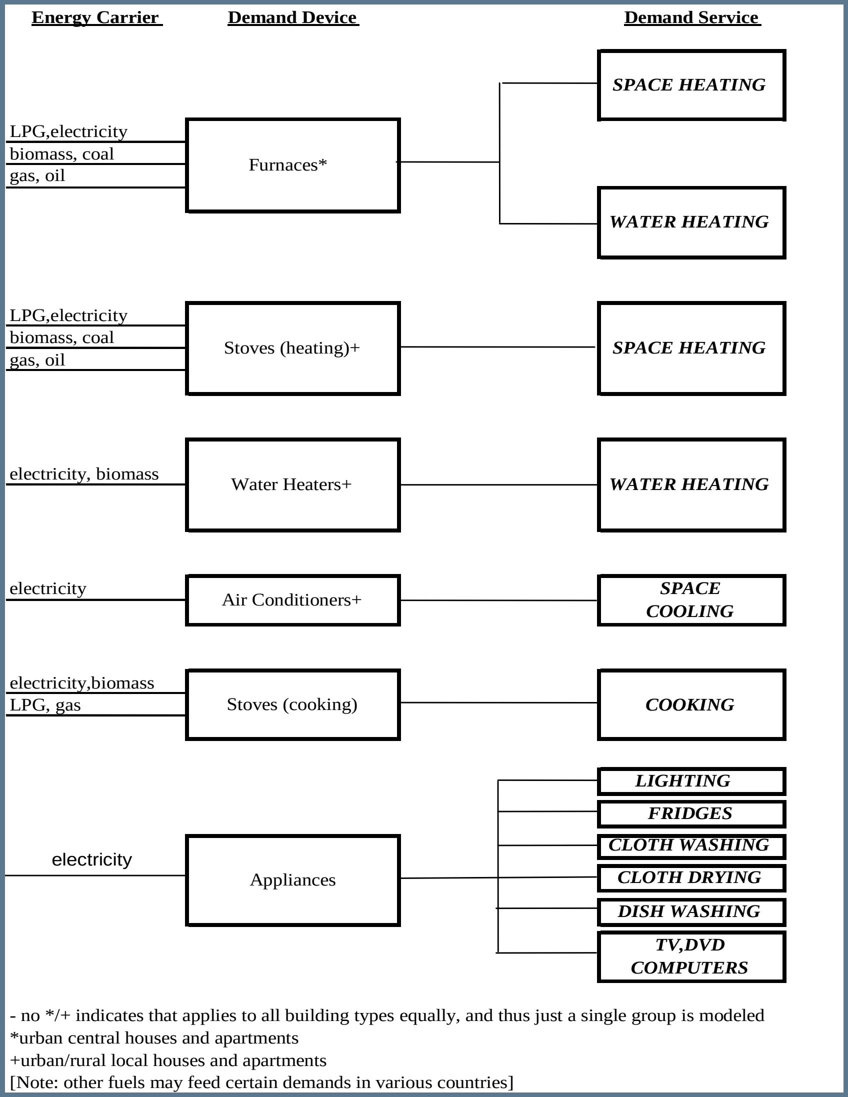
Energy Balance and the RES

- Special form of Energy Statistics
- Delineates the primary, secondary and final consumption of energy
  - Columns are energy forms
  - Rows are point in the RES
- Snapshot for a single year, with a series of energy balances showing trends
- The initial year RES modeled MUST calibrate to the corresponding energy balance

SEE-REDP Commercial RES



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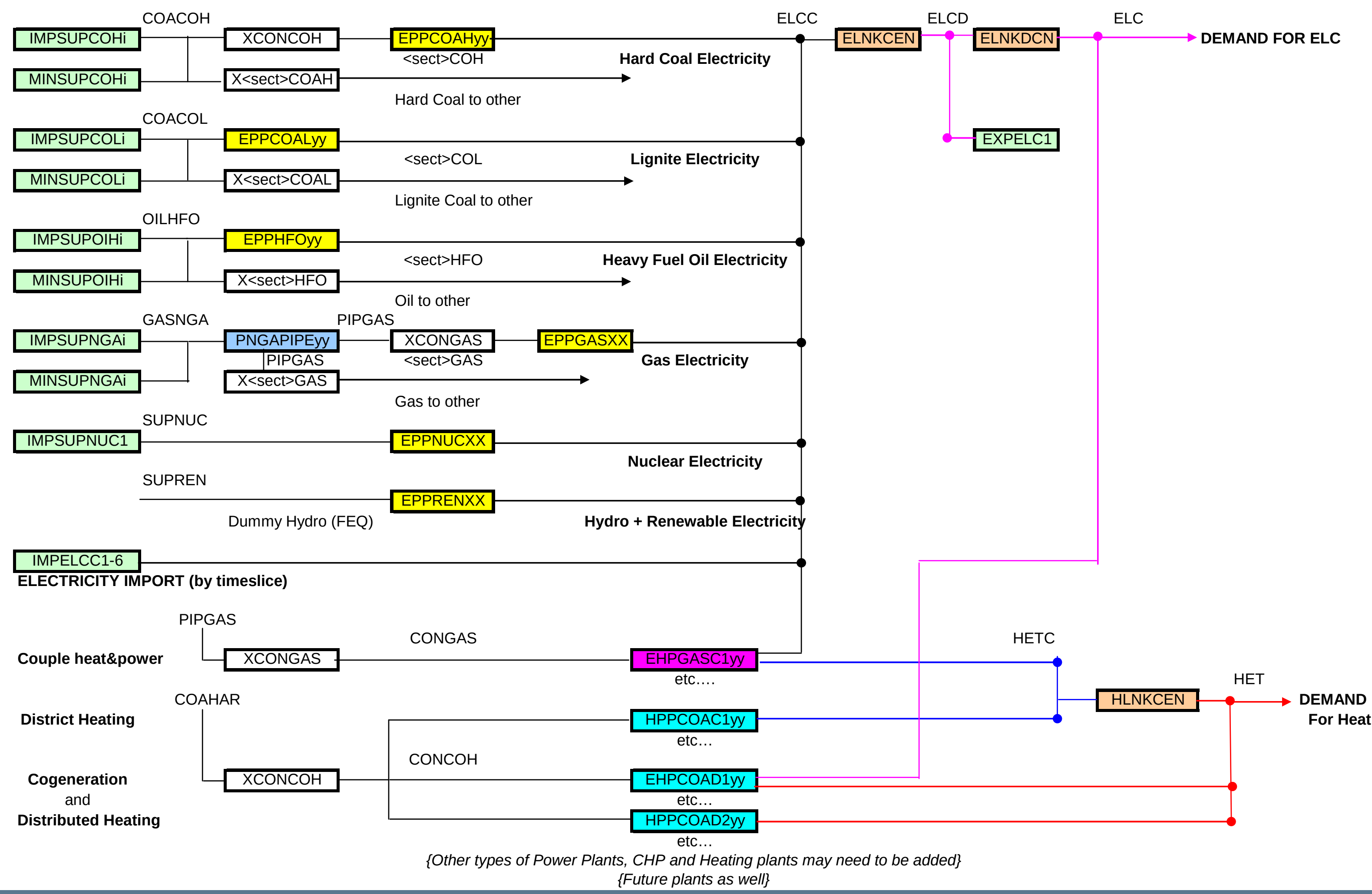
SEE-REDP Upstream RES

SEE-REDP (Simplified) Electricity and Heat Subsystem



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Goals of Calibration

- Reproduce energy balances (e.g., IEA, Eurostat, national statistics) corresponding to:
  - Primary energy delivered
  - Final energy consumed
  - Power sector energy consumption by fuel type
- Properly depict existing capacity in place and replicate initial year emission levels.

Calibration Components

- Technology specific data (existing capacity (RESID), utilization factor (CF), efficiency (EFF), etc.)
  - 100 gas furnaces consuming 0.5 PJ/yr
- End-use demand in physical units
  - Useful energy demand = sum of existing RESIDs (output)
- Final energy consumption by demand
  - Final demand = sum of existing device activity (RESID * CF) / EFF
- Primary energy production by energy carrier
  - Primary energy = sum for each RES energy chain of cascading fuel consumption
- Emission levels by fuel type and/or technology
  - Total emissions = technology activity/capacity/investment * emission rate
- Dummy sources for each energy carrier
  - To ensure no infeasibilities during the calibration process

Reference Scenario Activities

- Limit new investment in existing technologies
- Identify and describe the future resource supply and technology options
- Project future useful energy service demands
  - Establish the drivers for each sector
  - Introduce any saturation or adjustment factor
  - Apply to 1st year level over time
- Describe (and impose) all known builds
- Impose all known policies (e.g., emission limits, RPS, etc.)
- Smooth model behavior

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Reference Scenario Smoothing

- Impose limits on technology choice (penetration) by means of
  - Hard bounds on capacity/investment
  - Capacity growth/decay rates
  - (layered) market share group constraints
- Describe the load shape (for electricity and heat) of the demand sectors
- Review costs, as reflected by the calculated energy prices (shadow prices)

Overview of the Proposed Tools

- MARKAL/TIMES model generators, developed by ETSAP
  - Source code in GAMS modeling language
- GAMS modeling system and solvers
- “Smart” Excel workbooks
- User interfaces (“shells”) for managing input data, running the model, and examining results
  - ANSWER and/or VEDA

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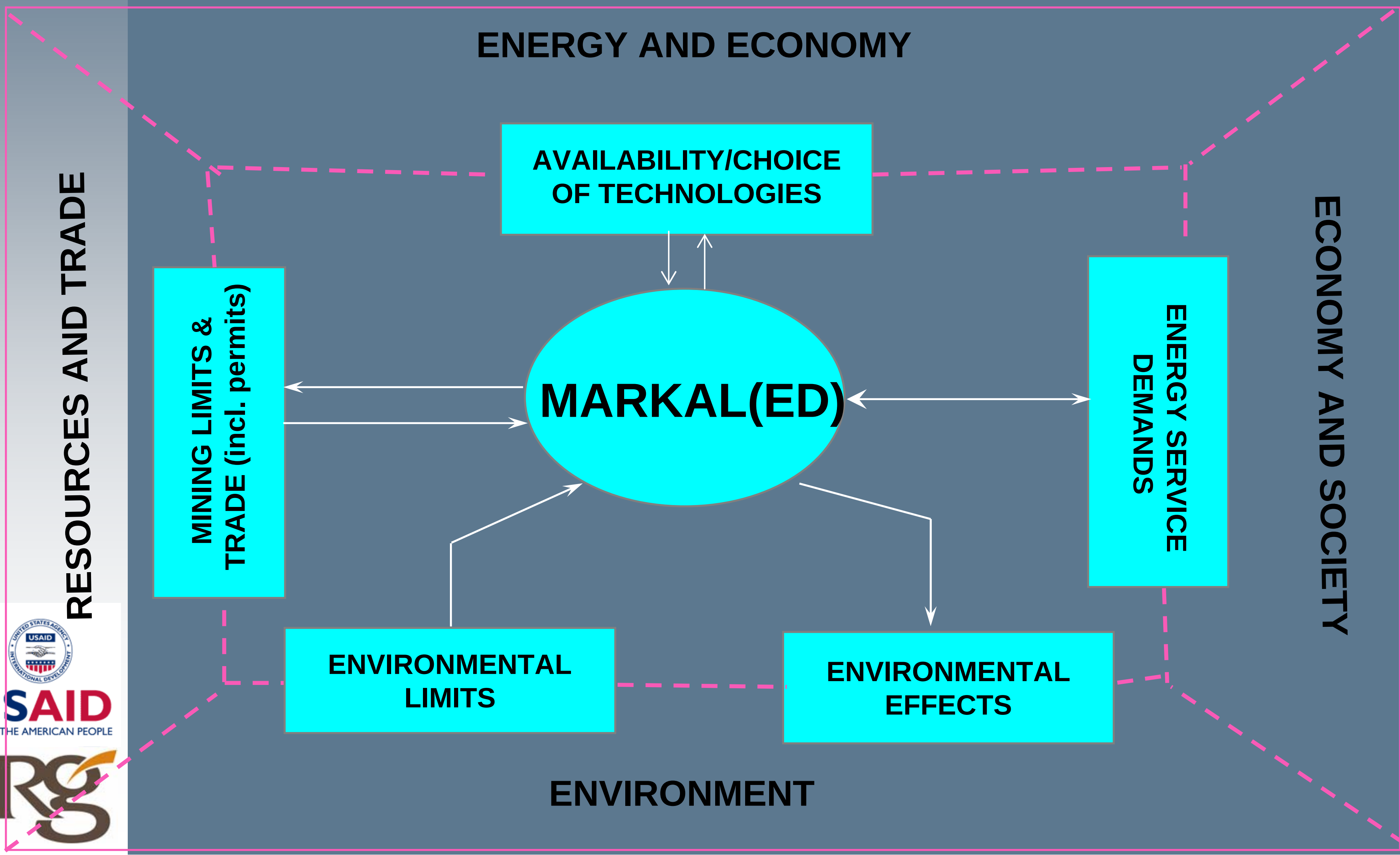
Summary of the Merits of MARKAL

- Widely used, proven and continually evolving model for assessing a wide range of energy and environmental planning and policy issues.
- Flexible, verifiable and adaptable methodology for supporting global, regional, national and local decision-making.
- Analytic framework is ideally suited for assessing the role of technology in achieving security, environmental and policy goals.
- Encompasses the entire energy (and materials) system to ensure a comprehensive assessment of inter-dependencies between sectors as they compete for limited resources (energy and fiscal), as well as the co-benefit arising from actions.

Assessing Energy, Economy, Environment & Trade Interactions

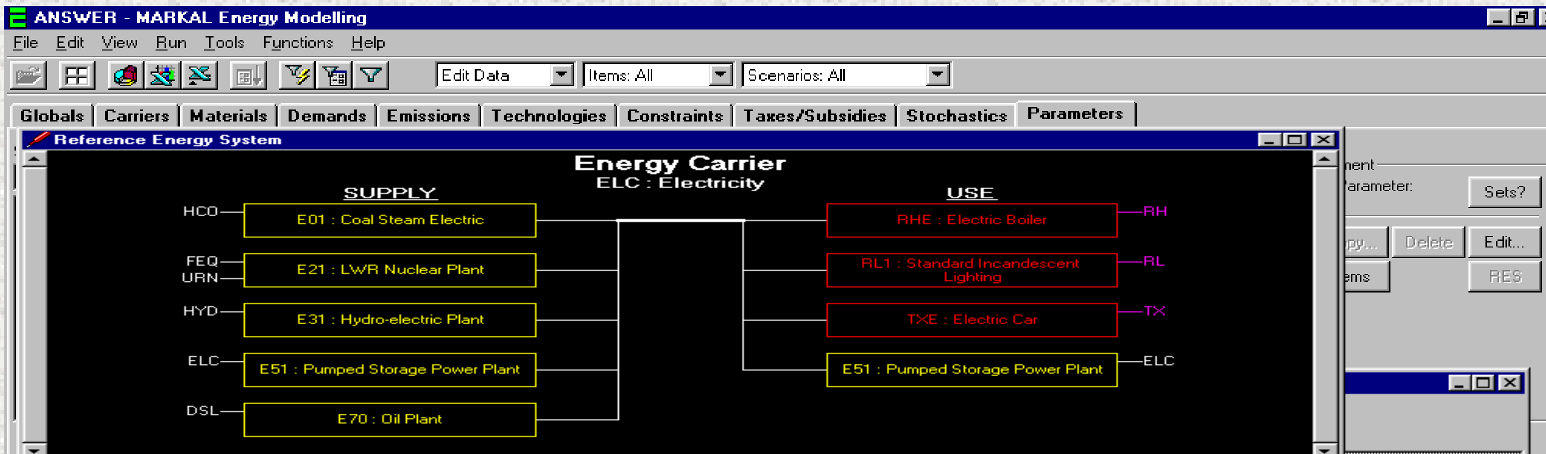


MARKAL Data Requirements

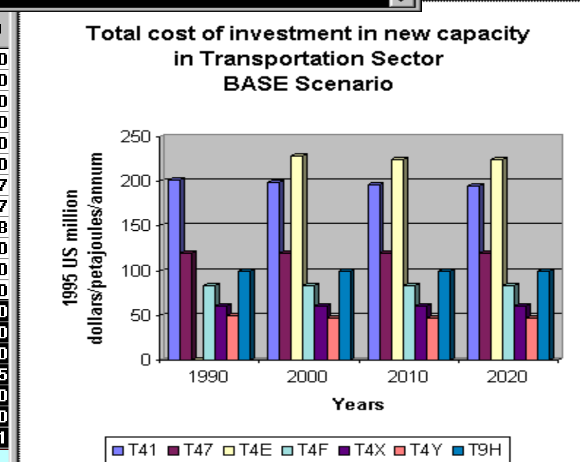
- Useful Energy Demands / Energy Services (and Elasticities)
- Detailed Costs
  - Resource, investment, fixed, variable, fuel delivery, hurdle rates
- Technology Characteristics
  - Fuels in/out, efficiency, availability, technical life duration
  - Resource supply steps, cumulative resources limits, installed capacity of technologies, new investment possibilities
- Environmental Impacts
  - Unit emissions per resource, per technology (operation, investment)
- System and other parameters
  - Discount rate, seasonal/day-night fractions, electric reserve margin

ANSWER Overseas Model Use

Network & Comparison of Technology Costs



	Scenario	Parameter		Technology	1990	2000	2010	2020
	BASE	INVCOST	?	R66	0.0000	120.0000	110.0000	100.00
	BASE	INVCOST	?	R67	52.0000	52.0000	52.0000	52.00
	BASE	INVCOST	?	R69	35.0000	35.0000	35.0000	35.00
	BASE	INVCOST	?	R6A	105.0000	105.0000	105.0000	105.00
	BASE	INVCOST	?	R85	80.0000	80.0000	80.0000	80.00
	BASE	INVCOST	?	R89	65.0000	65.0000	65.0000	65.00
	BASE	INVCOST	?	S22	1.0700	1.0700	1.0700	1.07
	BASE	INVCOST	?	S2A	1.9700	1.9700	1.9700	1.97
	BASE	INVCOST	?	S80	6.6800	6.6800	6.6800	6.68
	BASE	INVCOST	?	SF1	0.0000	1,300.0000	1,300.0000	1,300.00
	BASE	INVCOST	?	SF2	0.0000	1,500.0000	1,500.0000	1,500.00
	BASE	INVCOST	?	SF3	0.0000	1,700.0000	1,700.0000	1,700.00
	BASE	INVCOST	?	T41	201.3000	199.0000	196.7000	194.40
	BASE	INVCOST	?	T47	120.0000	120.0000	120.0000	120.00
	BASE	INVCOST	?	T4E	0.0000	229.0000	225.0000	225.00
	BASE	INVCOST	?	T4F	83.1500	83.1500	83.1500	83.15
	BASE	INVCOST	?	T4X	60.0000	60.0000	60.0000	60.00
	BASE	INVCOST	?	T4Y	49.3300	47.6000	47.6000	47.60
	BASE	INVCOST	?	T9H	98.9100	98.9100	98.9100	98.91
Add	BASE	INVCOST	?					



Database: C:\ANSWER\Answer Databases\SMATDEM3.MDB
Edit Scenario: BASE

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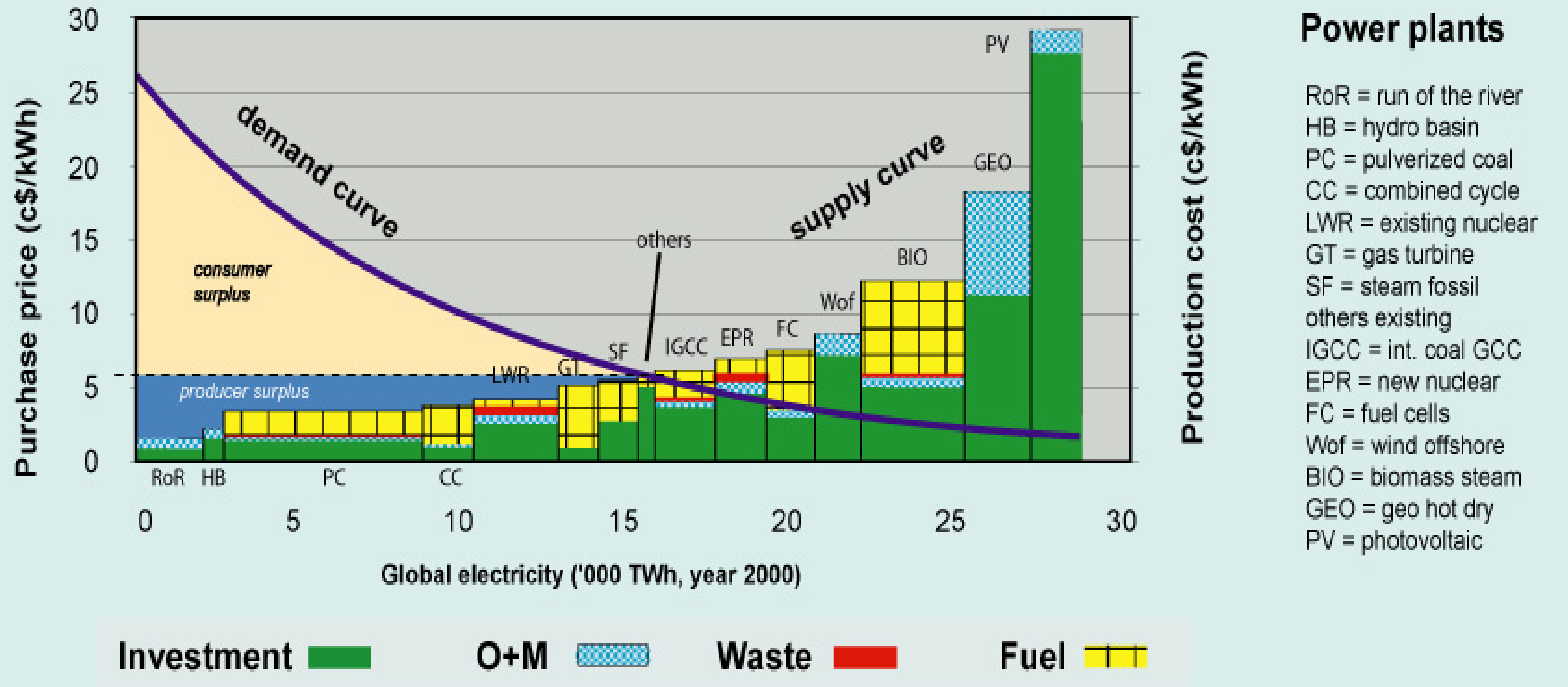
Producer/Consumer Equilibrium for each Commodity w/ Technology Detail



Typical representation of an energy commodity in MARKAL - TIMES.
The algorithm maximises the global surplus over thousands such markets.

Analysis – Examples of Results

- *Total primary energy*
- *Fuel consumption by demand sector*
- *Investments in new supply and demand technologies*
- *Electric generation by fuel type*
- *Annual expenditure throughout the energy system*
- *Total cost of the energy system*
- *Energy (marginal) prices*
- *Emission levels and sources*

SEE-REDP Accomplishments to Date

- Established a cooperative framework for developing in-country expertise for 8 SEE countries
- Developed consistent energy balances and "rational" detailed energy system data
- Developed a set of tools and processes for assembling the model data
- Constructed initial MARKAL/TIMES models for each of the participating countries
- Conducted an analysis examining the merits of policies to promote increased access to energy efficiency

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SEE-REDP Lessons Learned

- Challenges
  - Availability of Data (very data intensive)
  - Lack of TWG time (outside of the workshops), no junior staff or affiliate institutions, and changing participants
  - Steep learning curve to fully understanding how to use the model
- Integration of the new capabilities into the planning process is just now beginning in some of the countries
- Discussions underway on ways to sustain the capacity, and whether it should continue to reside directly within the Ministries or transferred to local (technical) institutions

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