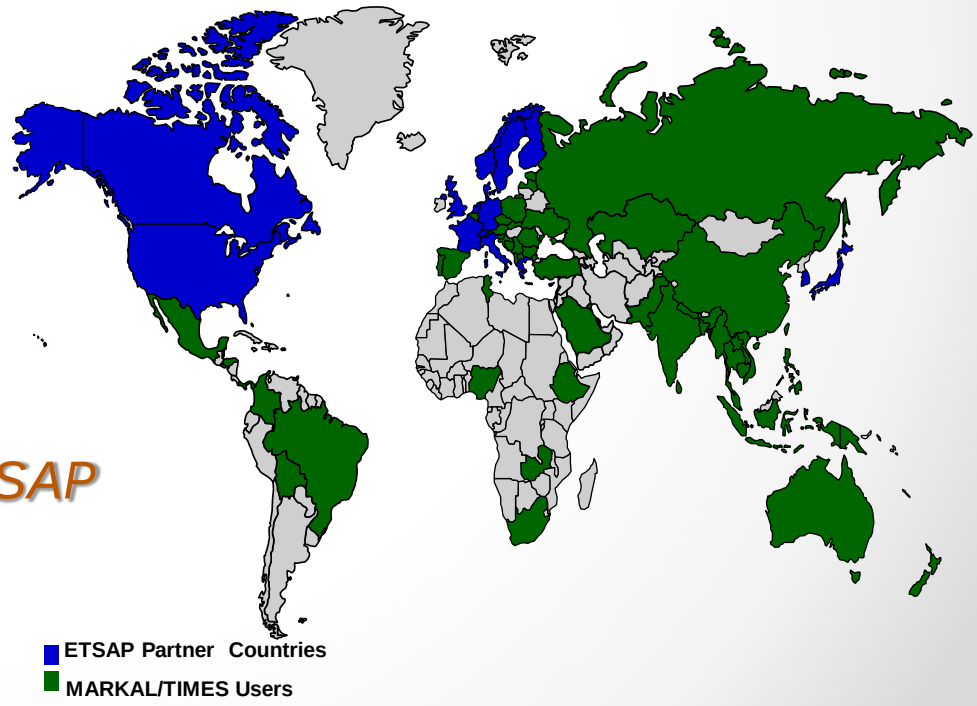
Overview of the MARKAL/TIMES Energy Systems Modeling Framework

DecisionWare Group LLC
Policy Analysis for
Energy, Economy and Environment

MARKAL/TIMES Modeling System

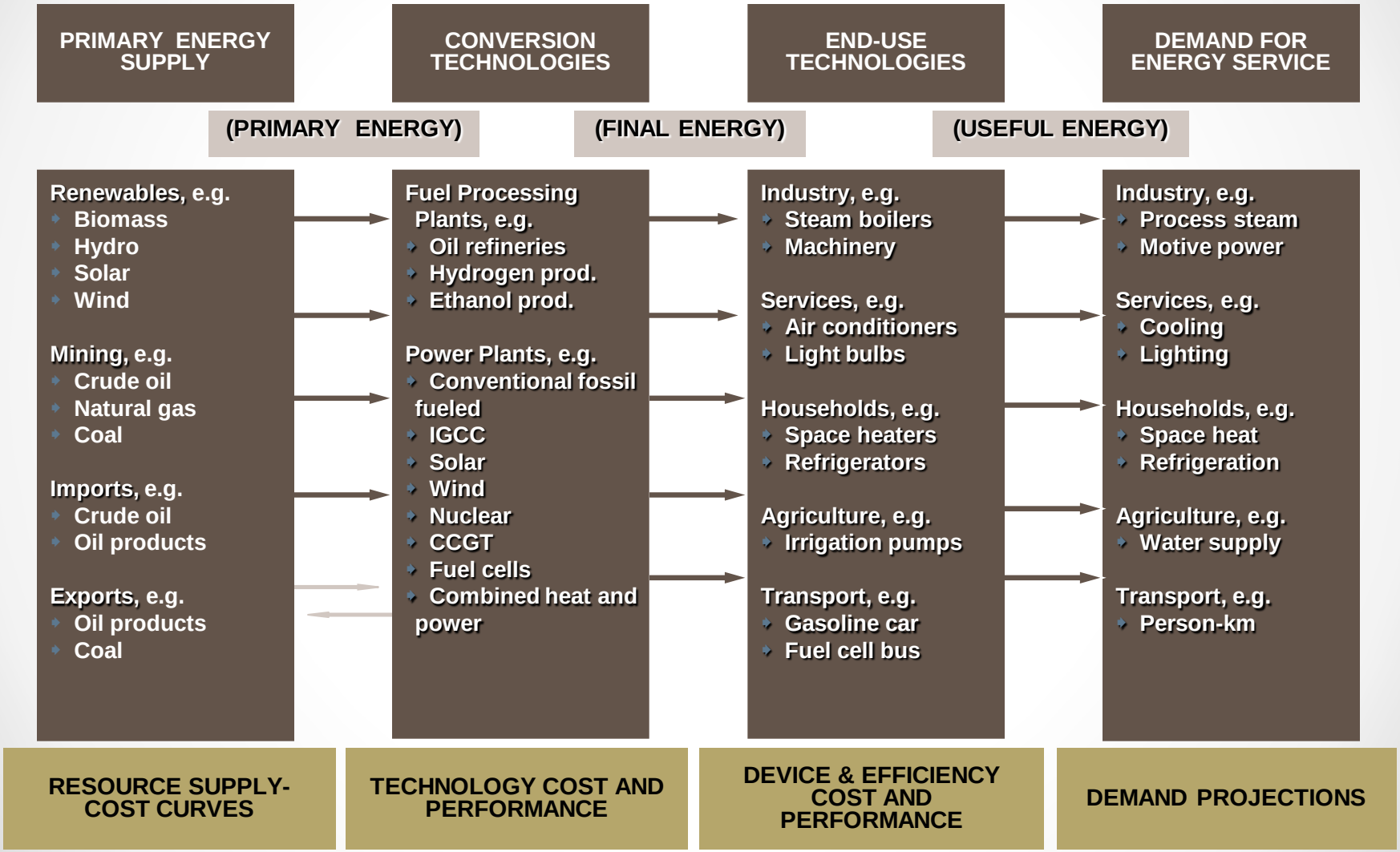
- An integrated energy systems modeling framework that is used to guide policy formulation and investment priorities within a comprehensive framework
- ***Widely used, proven*** and continually evolving framework for assessing a wide range of energy, economic and environmental planning and policy issues
- ***Flexible, verifiable and adaptable*** methodology for supporting global, regional, national and local decision-making
- MARKAL/TIMES tools are developed and maintained under the auspice of ***IEA-ETSAP***



Key Aspects of MARKAL/TIMES

- Encompasses an ***entire energy system*** from resource extraction through to end-use demands as represented by a Reference Energy System (RES) network
- Employs least-cost ***optimization***
- Identifies the most ***cost-effective*** pattern of resource use and technology deployment over time
- Provides a framework for the evaluation of mid-to-long-term ***policies and programs*** that can impact the evolution of the energy system
- Quantifies the ***costs and technology choices*** that result from imposition of the policies and programs
- Fosters ***stakeholder buy-in*** and consensus building

Reference Energy System



What are the key inputs?

- Characterization of the current stock of existing technologies
- Resource supply (step) curves, and cumulative resource limits
- The characterization of future technology options
  - Fuels in/out, efficiency, availability, technical life duration
  - Investment, fixed and variable O&M costs, and “hurdle” rates
  - Emission rates
  - Limits on technical potential
  - Performance degradation (e.g., efficiency, maintenance costs)
- Demand breakdown by end-use
  - Demand for useful energy
  - Own price (and income) elasticities
  - “Simplified” load curve
- Discount rate, reserve margin

What are the key Outputs?

- Total Discounted Energy System Cost
- Resources levels and marginal costs, if constrained
- Technology
  - Level of total installed capacity
  - Annual investments in new capacity and expenditure
  - Annual fixed and variable operating and fuel costs
  - Annual and season/time-of-day (for power plants) utilization
  - Marginal cost, if constrained
- Energy consumed by each technology (sector), and marginal price (by season/time-of-day for electricity)
- Demand marginal costs and change in levels, if using elastic MARKAL
- Emission level by resource/sector/technology for each period, and marginal costs, if limited

Major MARKAL/TIMES Undertakings

- International Energy Agency (IEA): Energy Technology Perspectives (ETP) report
- ETSAP TIMES Integrated Assessment Model (TIAM): EMF-22 development of hedging strategies and UNFCCC Working Group 3
- European Fusion Development Agreement (EFDA) consortium
- US National Model: Examination of GHG reduction proposals under consideration in the US Congress
- Natural Resources Canada: National Climate Change Implementation Process
- UK Department of Trade and Industry for “Options for a Low Carbon Future”
- U.S. EPA-ORD US9r modeling: Climate Change Air Quality Assessment (AQA
- BNL on behalf of DOE Office of EERE, Fossil, Nuclear; evaluate technology choices
- Majority of OECD including most all EU countries, Japan, South Korea, etc
- EC NEEDS (New Energy Externalities Development for Sustainability) project:
- 28 states Pan-European TIMES model; examine renewable energy targets (RES2020) and energy security (REACCESS))
- AUSAID/ASEAN: Energy Policy Systems Analysis Project (EPSAP); 8-country + regional center (ACE) capability building and planning initiative.
- USAID Southeast Europe Regional Energy Demand Planning project; established national planning models for Albania, Bosnia, Croatia, Macedonia, Serbia, Kosovo, Romania and Bulgaria; follow-on project added Georgia, Moldova and Ukraine