Energy Sector Strategic Planning for Georgia using MARKAL Model.

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“WEG”

SYNENERGY STRATEGIC PLANNING

- Energy Community Contracting Parties
  - Albania
  - Bosnia-Herzegovina
  - Bulgaria
  - Macedonia
  - Montenegro
  - Romania
  - Serbia
- Energy Community Observer Countries
  - Georgia
  - Moldova
  - Ukraine

ENERGY PLANNING
ENERGY SUPPLY

- All types of fuels
  - Electricity
  - Natural gas
  - Oil and oil products
  - Coal
  - Wood
  - LPG
  - Renewables
  - Etc.
- Supply technologies
  - Production
  - Import
  - Transformation- Power plants, refineries etc.
  - Transmission
  - Distribution
  - Consumption equipment

ENERGY PLANNING
ENERGY USE

- Sectors of Economy
  - Residential
  - Industrial
  - Commercial (Services, retail, education, etc.)
  - Agriculture
  - Transport
- End Uses
  - Heating
  - Cooling
  - Lighting
  - Hot water
  - Refrigeration
  - Industrial heat
  - Mechanical power
  - Cooking
  - Etc.
  - Export

DESCRIPTION OF MARKAL

MARKAL (acronym for MARKet ALlocation) is a widely applied bottom-up, dynamic technique, originally and mostly linear programming (LP) model developed by the Energy Technology Systems Analysis Program (ETSAP) of the International Energy Agency (IEA) .

MARKAL is:

- "bottom-up" optimization model of the entire energy system of a single or several regions
- technology rich model, depicting the comprehensive energy system including
  - supply (imports/production)
  - upstream (refineries, power plants, and pipelines and grids)
  - demand devices providing demand services (e.g., heaters, lights, machine drives, cars)

SCENARIO ASSESSMENT APPROACH

- Scenario analysis NOT prediction
- Forecast period till 2050 (currently up to 2030)
- Takes into account driving forces (demand drivers):
- Technological change
- Energy supply and price dynamics
- GDP growth rate and population growth rate projections

KEY MARKAL FEATURES

- Provides a coherent and transparent framework
- Data assumptions are open and each result can be traced back to its technological roots
- Is flexible (facilitates “What if?” questions)
- Has long history (>20 years) of widespread use (>50 countries)

WHAT DOES MARKAL DO?

- Covers an **entire energy system** from resource extraction to end-use demands as represented by Reference Energy System 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
- Key function: minimize PV of all future costs related to satisfying projected demand for energy services over a forecasted period.

WHAT QUESTIONS CAN MARKAL ANSWER?

- What happens if a new technology becomes available, or if an old one becomes cheaper or more efficient?
- What level of investment will be necessary in the power sector to support higher economic growth?
- The role of energy efficiency, and what is the resulting reduction in energy supply, power plant investments and fuel expenditures?
- What policies are needed to reach Renewable Portfolio Standards' targets, and what will they cost?

WHAT QUESTIONS CAN MARKAL ANSWER?

What are the benefits of regional market integration?

- Opportunities for increasing exports
- Implications for energy diversity and security of supply
- Impact of an integrated electricity network on power sector investment requirements

… and others

HOW MARKAL WORKS?

Objective: Minimize aggregate system costs (capital+ operating+ fuel)

Subject to various constraints:

System: energy balance, demands, electrical system operation

User-imposed: emissions cap, technology portfolio standards, taxes, subsidies

HOW MARKAL WORKS?

- Represents all energy producing, transforming, and consuming processes as an interconnected network (Reference Energy System RES)
- Selects technologies to meet end-use service demands based on life cycle costs of competing alternatives

OVERVIEW OF SOFTWARE TOOLS

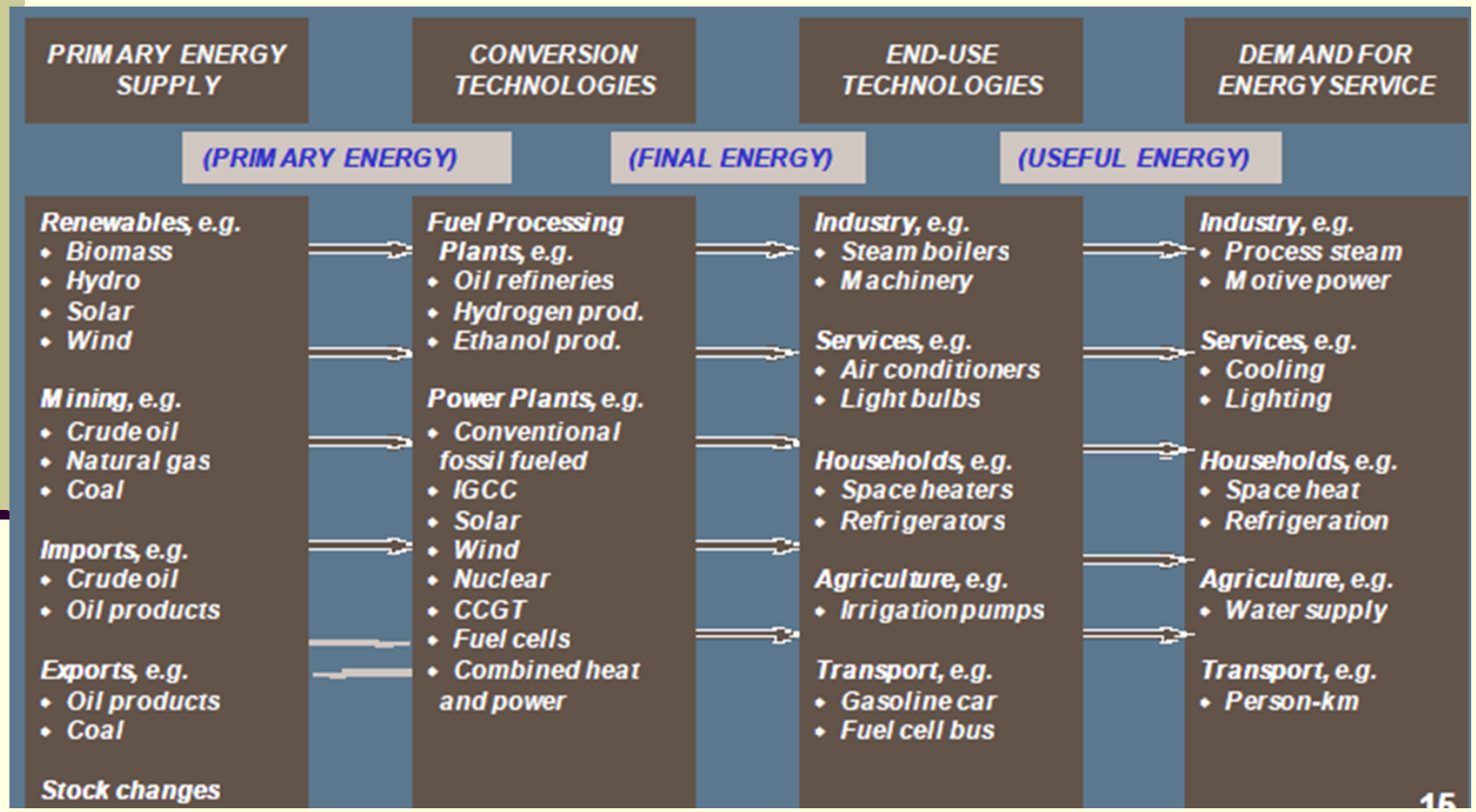
- MARKAL model generator, developed by Energy Technology Systems Analysis Program (ETSAP)

Source code in GAMS modeling language

- The General Algebraic Modeling System (GAMS)
- “Smart” Excel workbooks
- User interfaces (“shells”) for managing input data, running the model, and examining results
  - ANSWER and/or VEDA

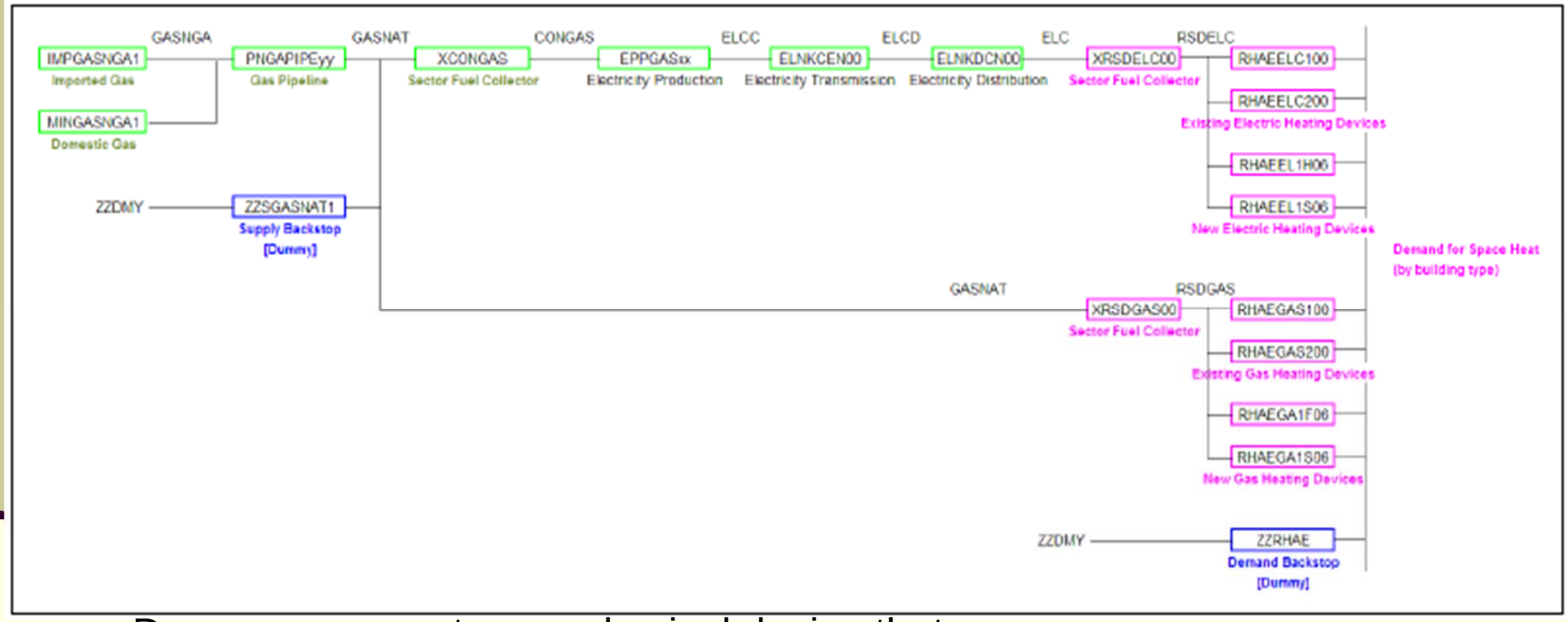
REFERENCE ENERGY SYSTEM COMPONENTS

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



SSP RES SNAPSHOT

USE OF NATURAL GAS AND ELECTRICITY FOR APARTMENT SPACE HEATING



Dummy represent a nonphysical device that consumes an inexhaustible, nonphysical fuel and that can meet any amount of demand at very high cost.

MARKAL DATA REQUIREMENTS

- National Energy balance and consumption by subsector, and the splits down to the end-use level
- Useful Energy Demands / Energy Services (and Elasticities), and time of use
- Detailed Costs
  - Resource, investment, fixed, variable, fuel delivery
- 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

ANALYSIS – SAMPLE RESULTS

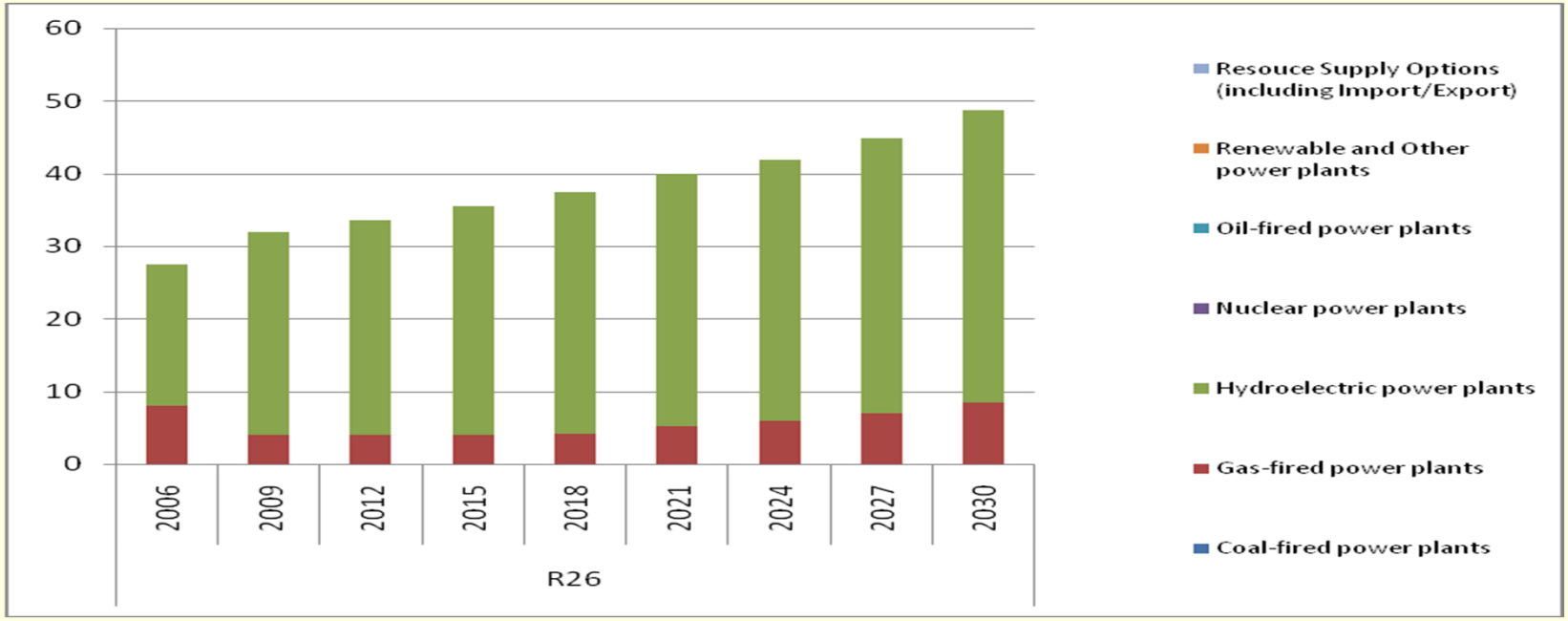
- *Total primary energy*
- *Fuel consumption by demand sector*
- *Investments in new supply and demand*
- *technologies*
- *Electric generation by fuel type*
- *Annual expenditure throughout the energy system*
- *Total cost of the energy system*
- *Energy (marginal) prices*
- *Emission levels and sources*

SCENARIOS

- Reference
- Energy efficiency
- Renewables
- Energy efficiency+ renewables
- Country specific (for Georgia– possibility of electricity swap)

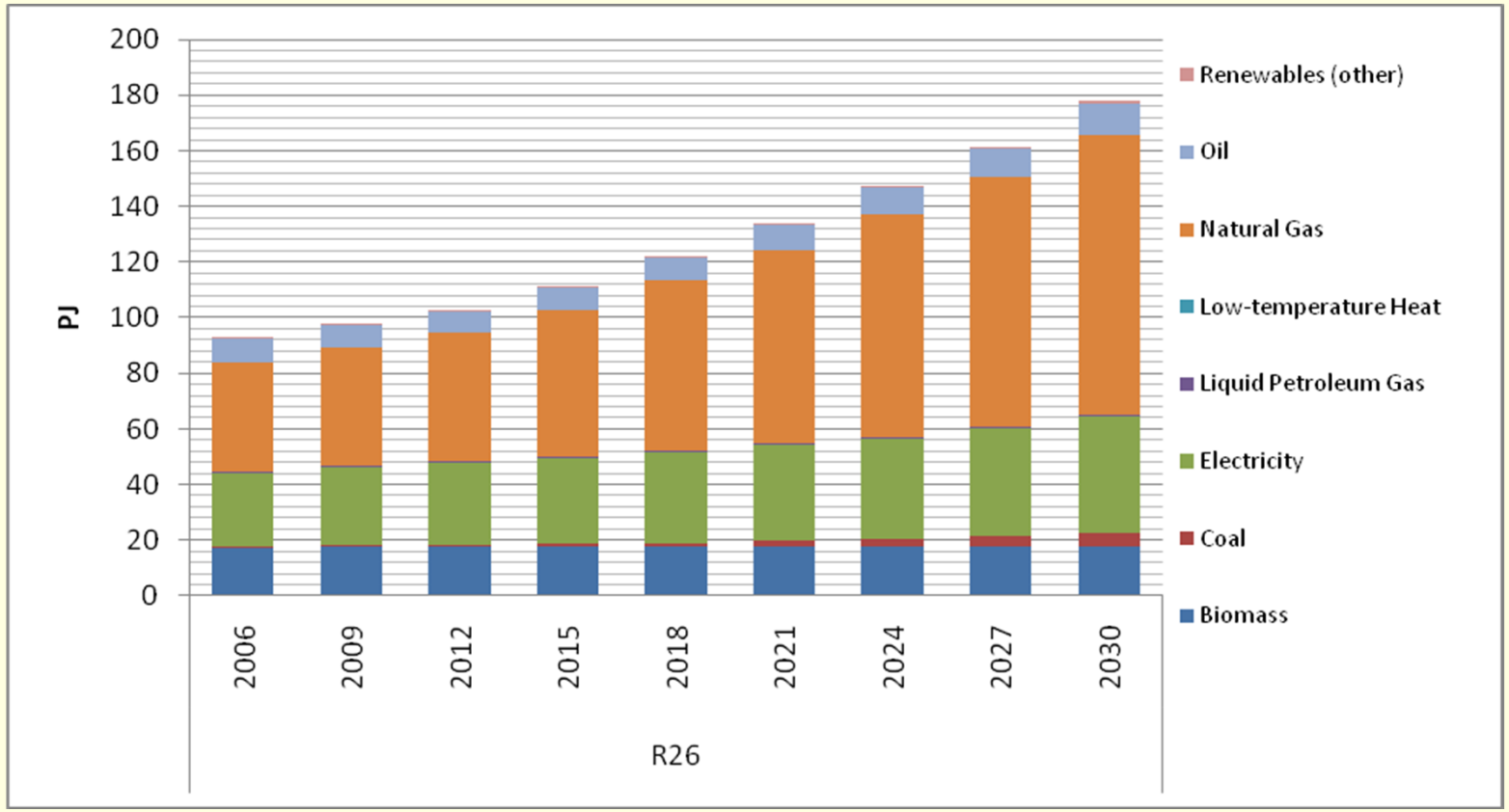
SAMPLE RESULTS GEORGIAN CASE

Electricity generation by fuel type, GWh



SAMPLE RESULTS GEORGIAN CASE (CONT.)

- Final Energy Consumption by Fuel [PJ]



THANK YOU!

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