



Introduction to MESSAGE

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MESSAGE

Model for Energy Supply Strategy Alternatives and their General Environmental impacts

A modelling framework designed for setting up optimization models of energy system to evaluate capacity expansion and energy production strategies

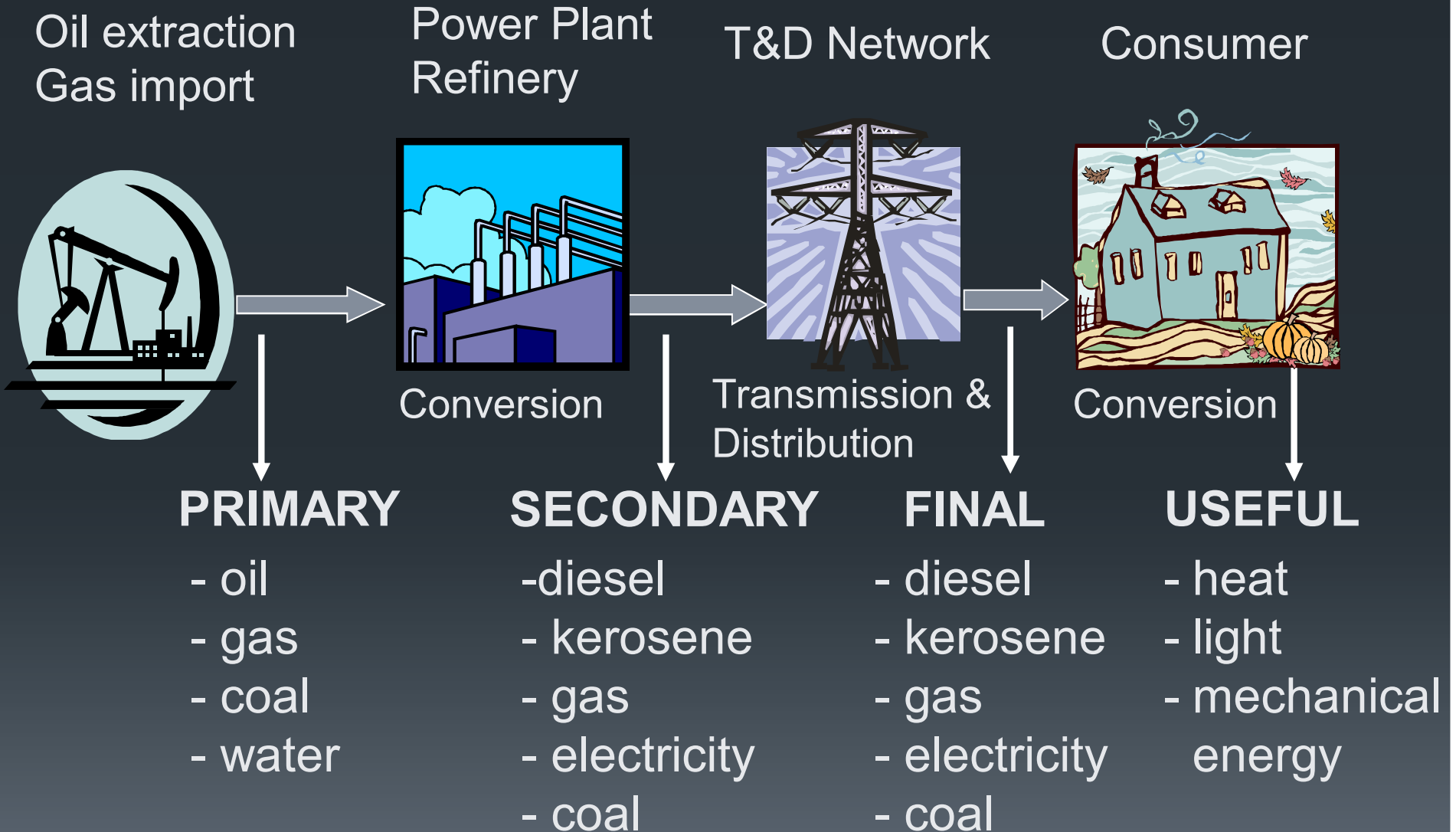
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Physical Flow Model

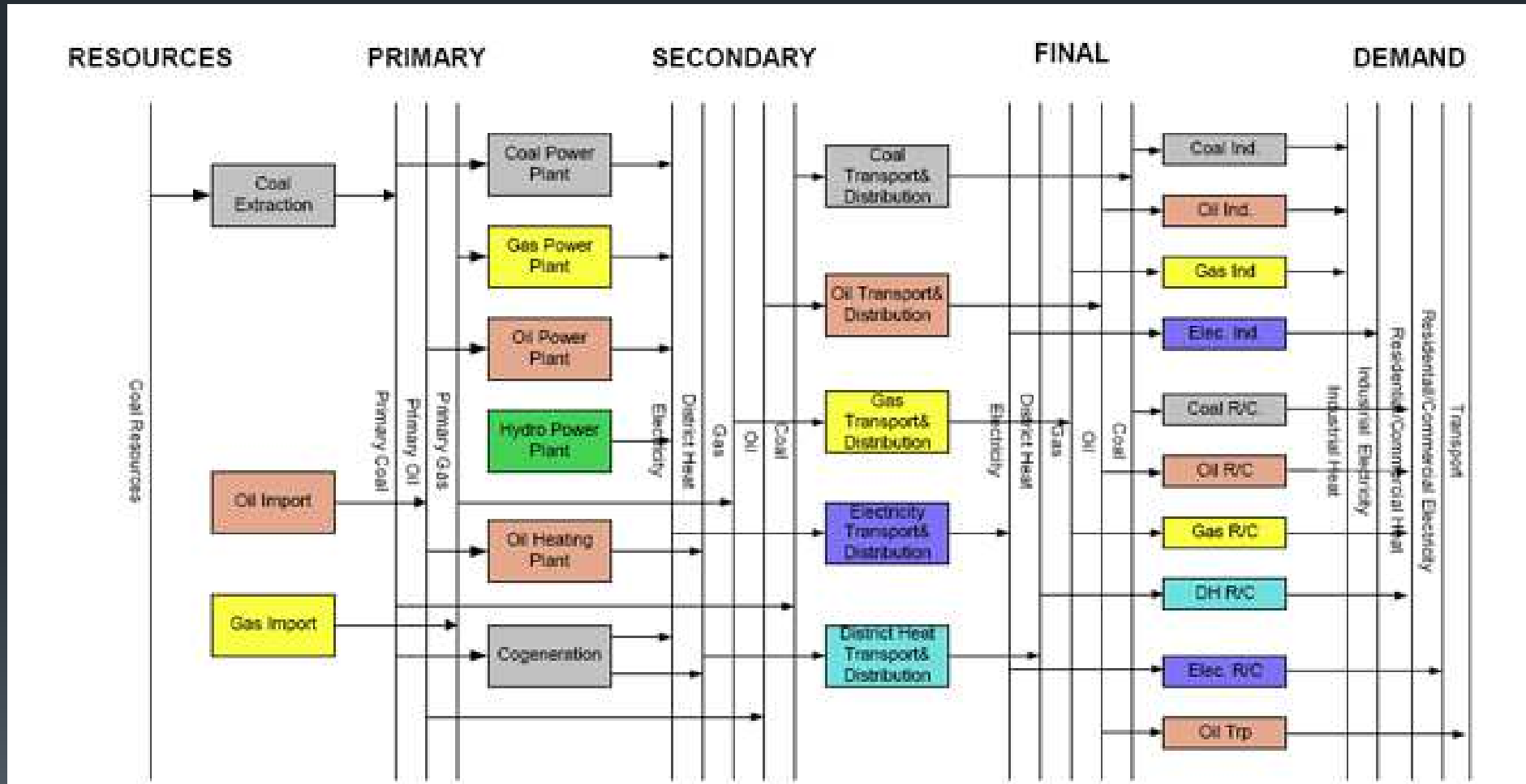
For a given vector of demands for goods and services, it assures sufficient supplies utilizing available technologies and resources

Based on specified criterion, it optimizes the system expansion and operation

Energy Chain



Energy Chains in MESSAGE



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- **Criterion**

Cost minimization

Profit maximization

Multi-objective optimization

- **Mathematical Techniques**

Linear programming

Mixed-integer programming

Non-linear programming

Modelling Framework



- Time frame
- Load regions
- Load Curves
- Energy levels
- Energy forms
- Technologies
- Resources
- Demands
- Constraints (Relations)

Time Frame

- Study period is divided into Time Steps
- Time Steps can be of varying lengths
- A base year is needed to specify initial conditions

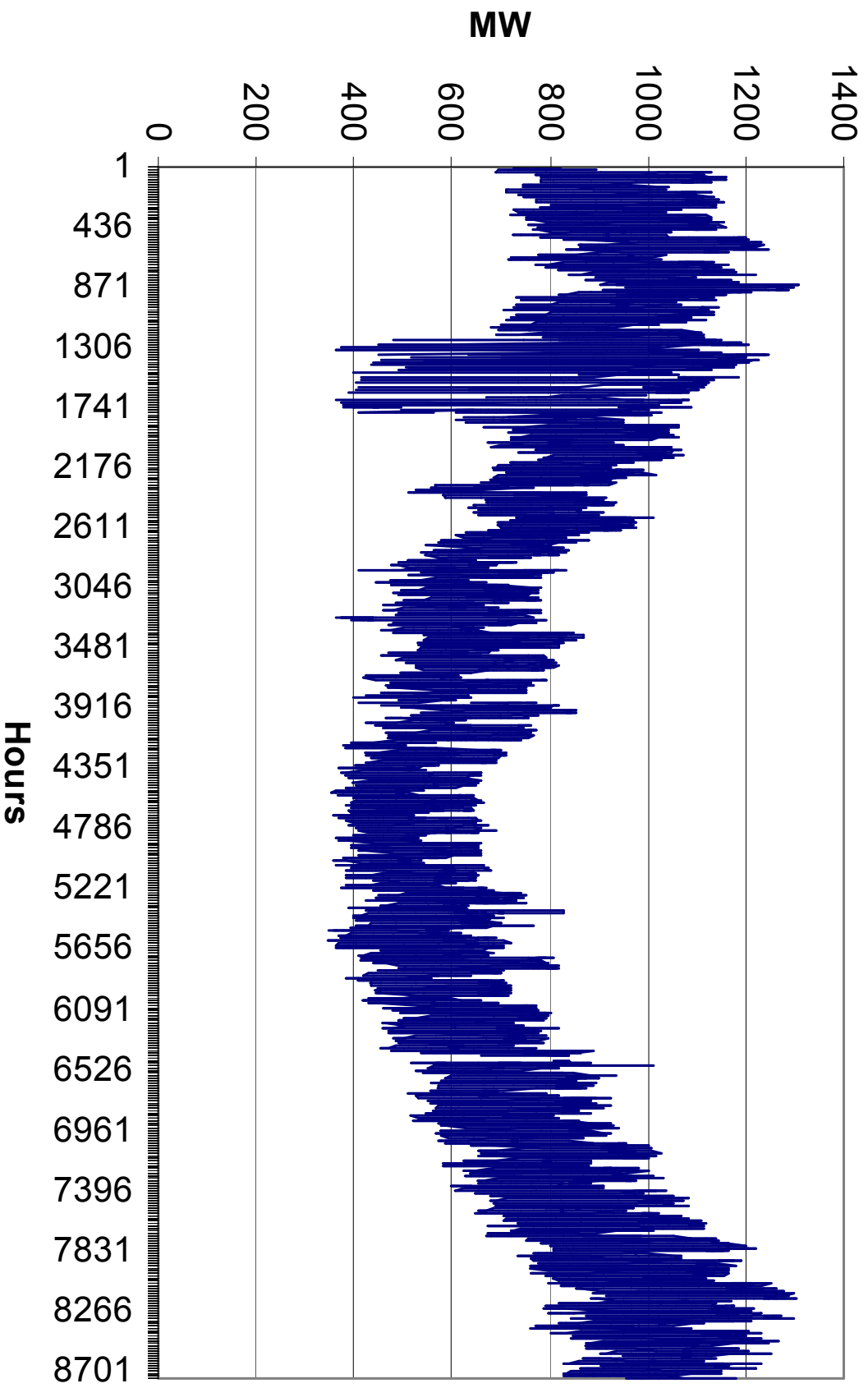


Load Regions

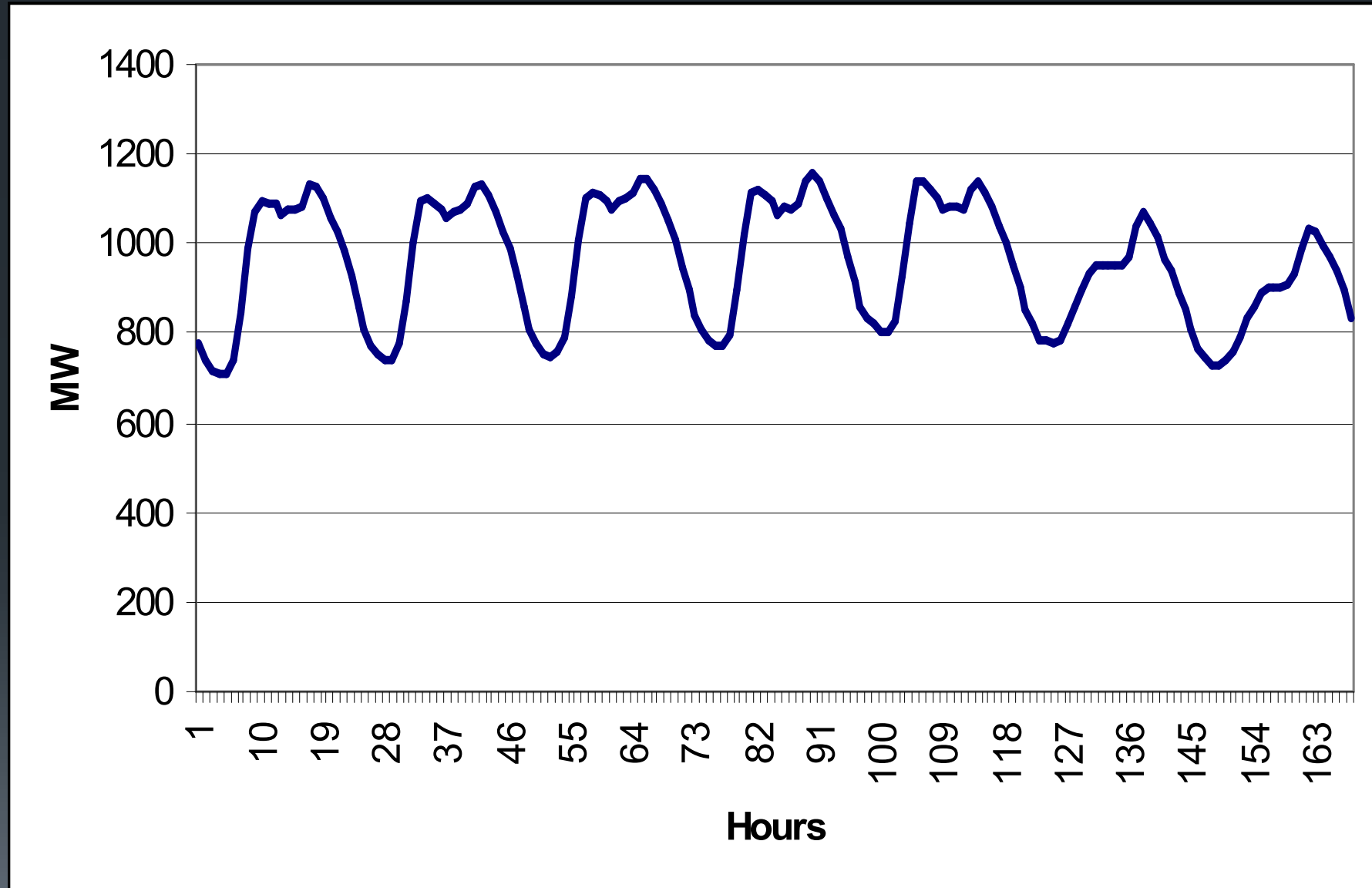


- **Load Variation during a year can be represented by Load Regions and Load Curves**
- **Each Year can be divided into several Load Regions; seasonal, chronological, ordered**
- **Number of Load Regions may vary for different years**

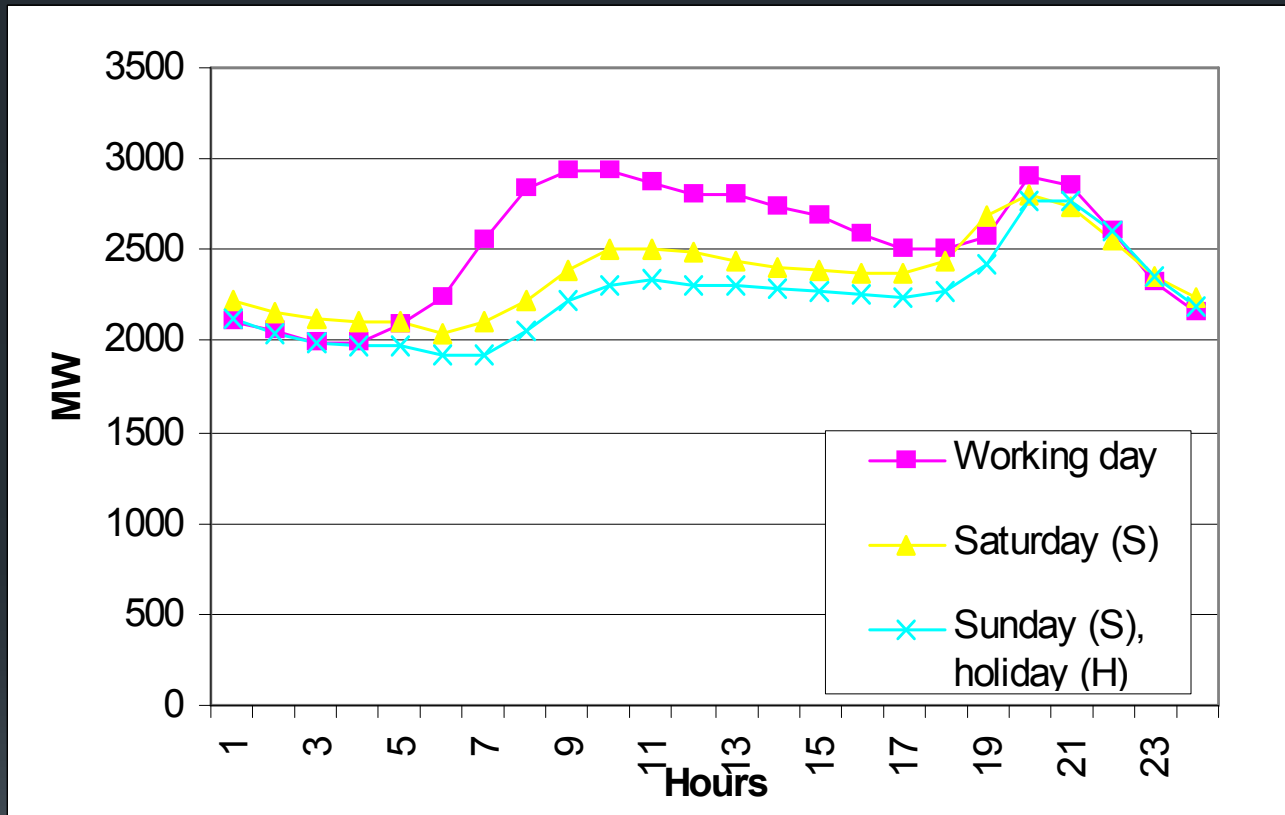
Variation of electricity demand



Variation of electricity demand

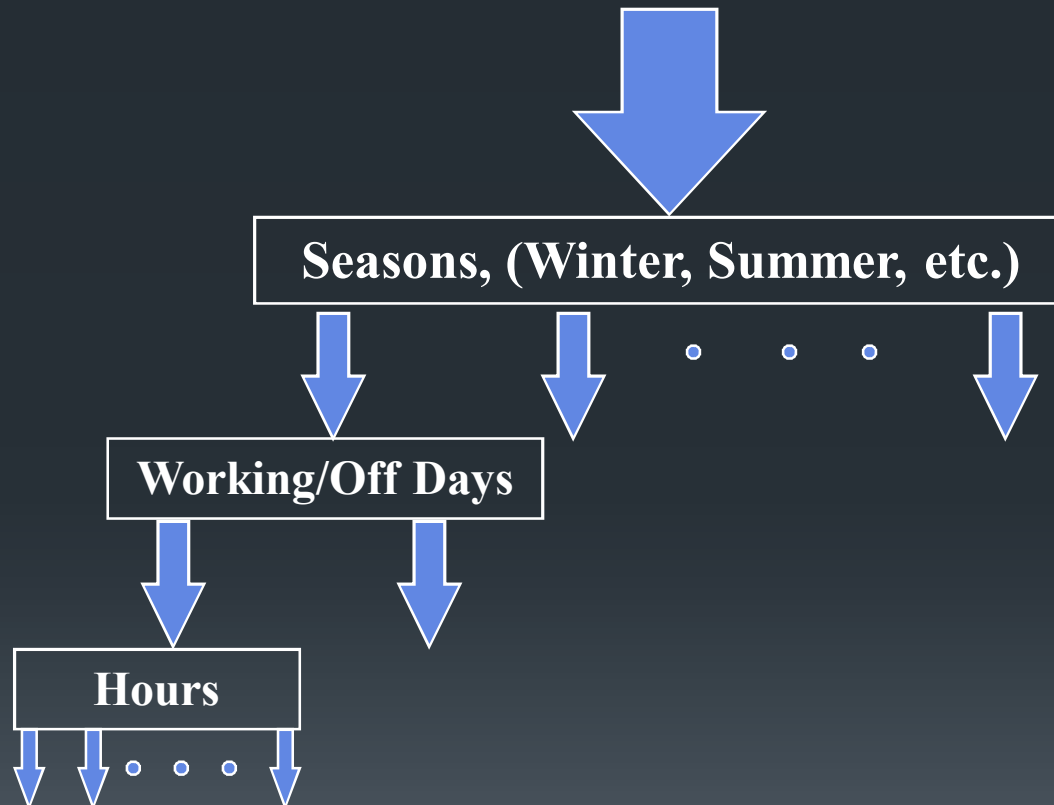


Variation of electricity demand



Load Regions

Seasonal Division of Year



Load Curves

For each Load Region already specified,

**Variation of demand for certain fuels within
a year**

e.g. Electricity, Heat, Gas

Energy Levels & Energy Forms



Various Energy Forms/Fuels can be organized/grouped into different Energy Levels for easy and systematic recognition, e.g.

**Primary Gas,
Secondary Electricity,
Final Electricity**

Conversion Technologies

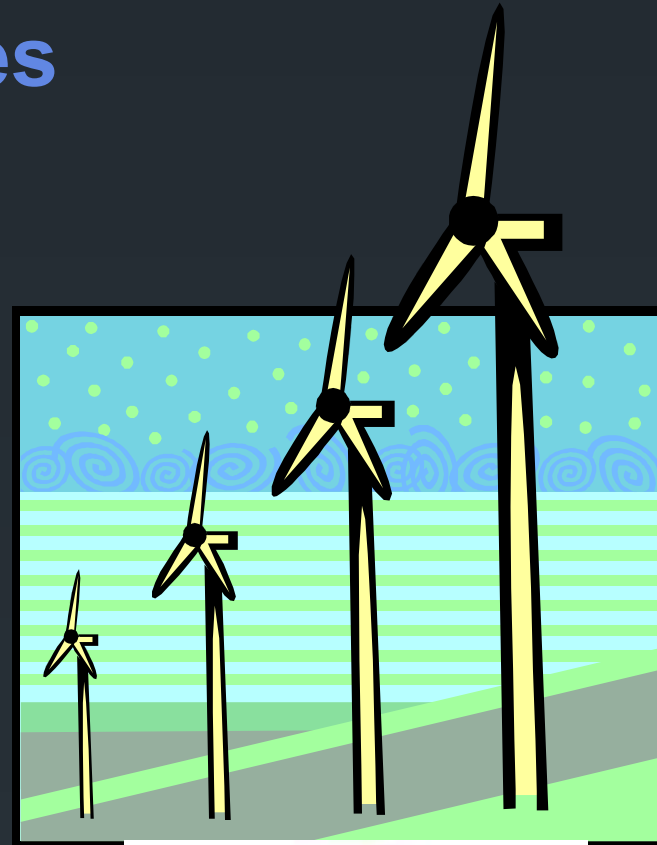


All energy technologies can be modelled

- Multiple inputs and outputs
- Seasonal variation in capability
- Efficiency varying with time
- Costs varying with time
- Limits on production
- Capacity build-up constraints
- Market penetration
- Environmental Regulation

Renewable Technologies

- Renewable technologies can be represented with intermittent production
- Can be linked with storage or back-up systems

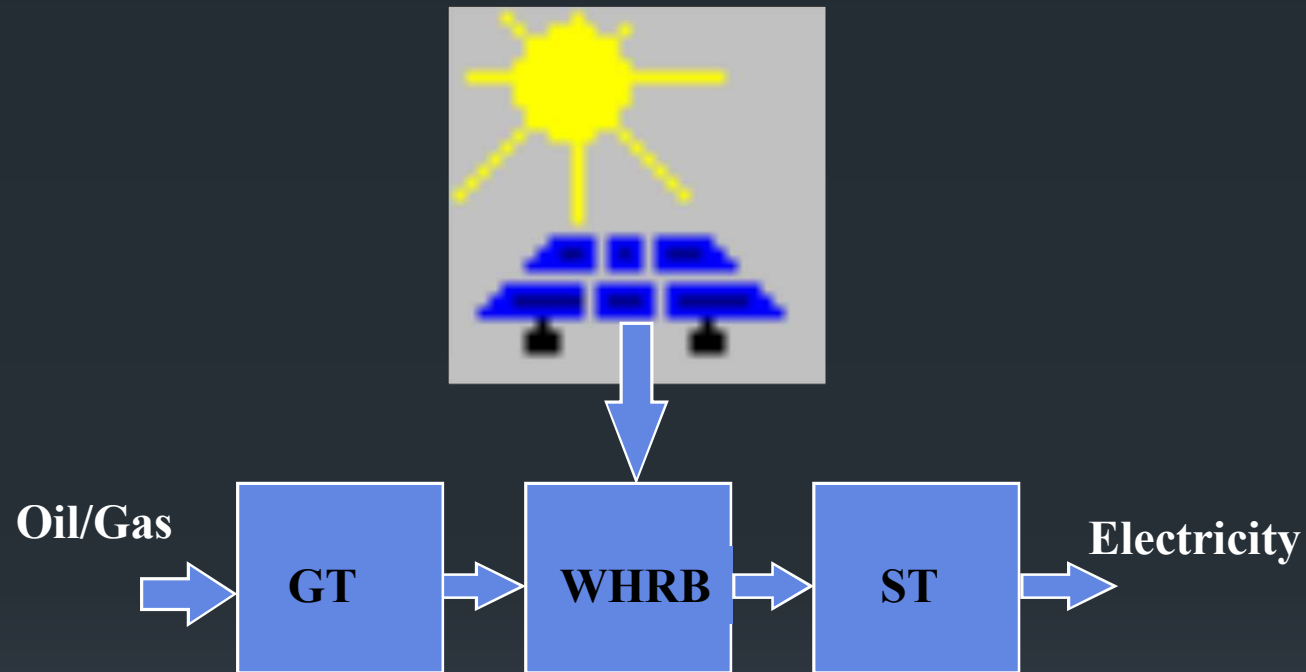


Renewable Technologies

- **Renewable technologies can be scaled-up and connected to Grid**
- **Can be linked with storage or back-up systems**



Hybrid Solar-Fossil Combined Cycle



- Hybrid plants can be represented with temporal availability of renewable source

Energy Trade



- **Imports-Exports of Fuels**
- **Fuel Prices varying within a year and over years**
- **Imports-Exports from/to different countries/region at different prices**
- **Market penetration**

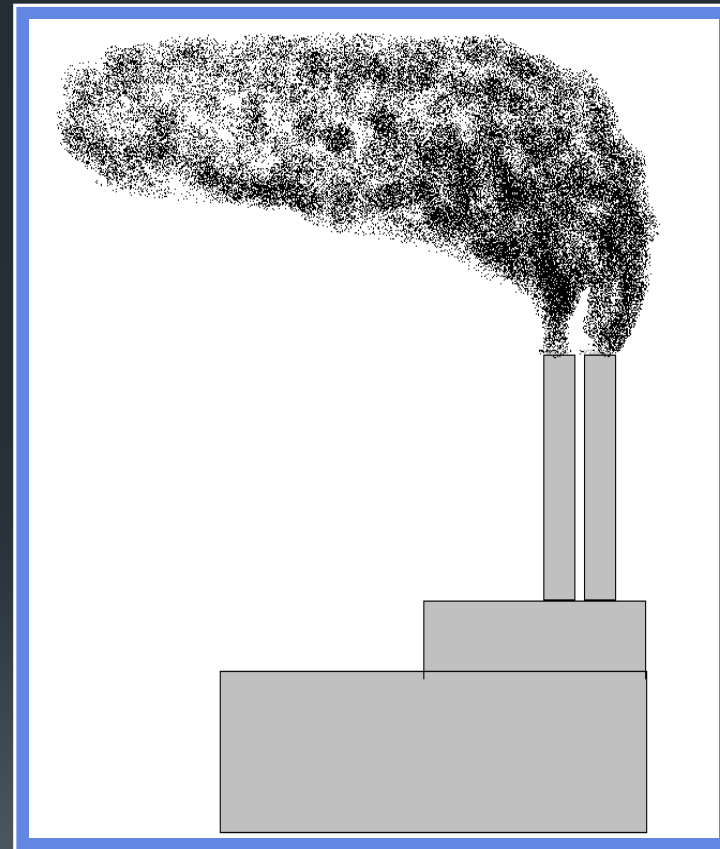
Depletable Energy Resources



- **Various energy resource can be grouped into different Grades**
- **Grades based on geographic locations, or geological uncertainty**
- **Resource extraction constraints; linked to total remaining amount or previous year's extraction level, or specific annual limits**

Modelling Environmental Regulations

- **Emission control limits can be imposed on Individual Plants or Group(s) of Plants**
- **Emission trading among plants/utilities possible, but more complicated**



Modelling Climate Policies

- **GHG Emission limits can be imposed and Emissions can be penalised.**
- **GHG Emission trading can also be analysed**



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INPUT

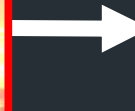
Energy system structure (including vintage of plant and equipment)

Base year energy flows and prices

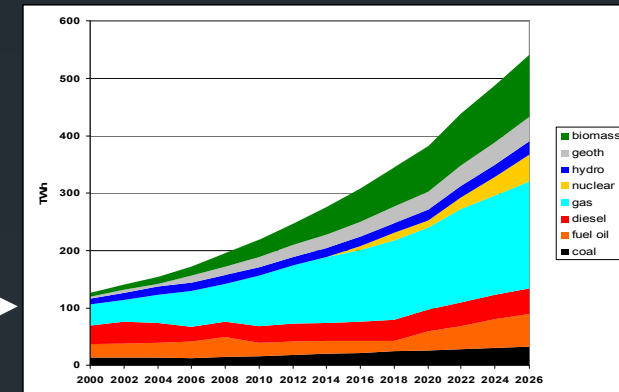
Energy demand projections (MAED)

Technology and resource options & their techno-economic performance profiles

Technical and policy constraints



OUTPUT



Primary and final energy mix

New Capacity additions

Resource use

Land, Water & other material use

Emissions and waste streams

Import dependence

Investment requirements



**MESSAGE Provides a very Flexible
Modelling Framework for Evaluating
Alternative Energy Strategies and
Policies**