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**OVERVIEW OF THE INTEGRATED PLANNING
MODEL (IPM)**

**NIS Institutional Based Services Under the Energy
Efficiency and Market Reform Project
Contract No CCN-Q-00-93-00152-00**

Joint Russian-American Energy Alternatives Study

Delivery Order No 2

Presentation

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Office of Environment, Energy and Urban Development
Energy and Infrastructure Division

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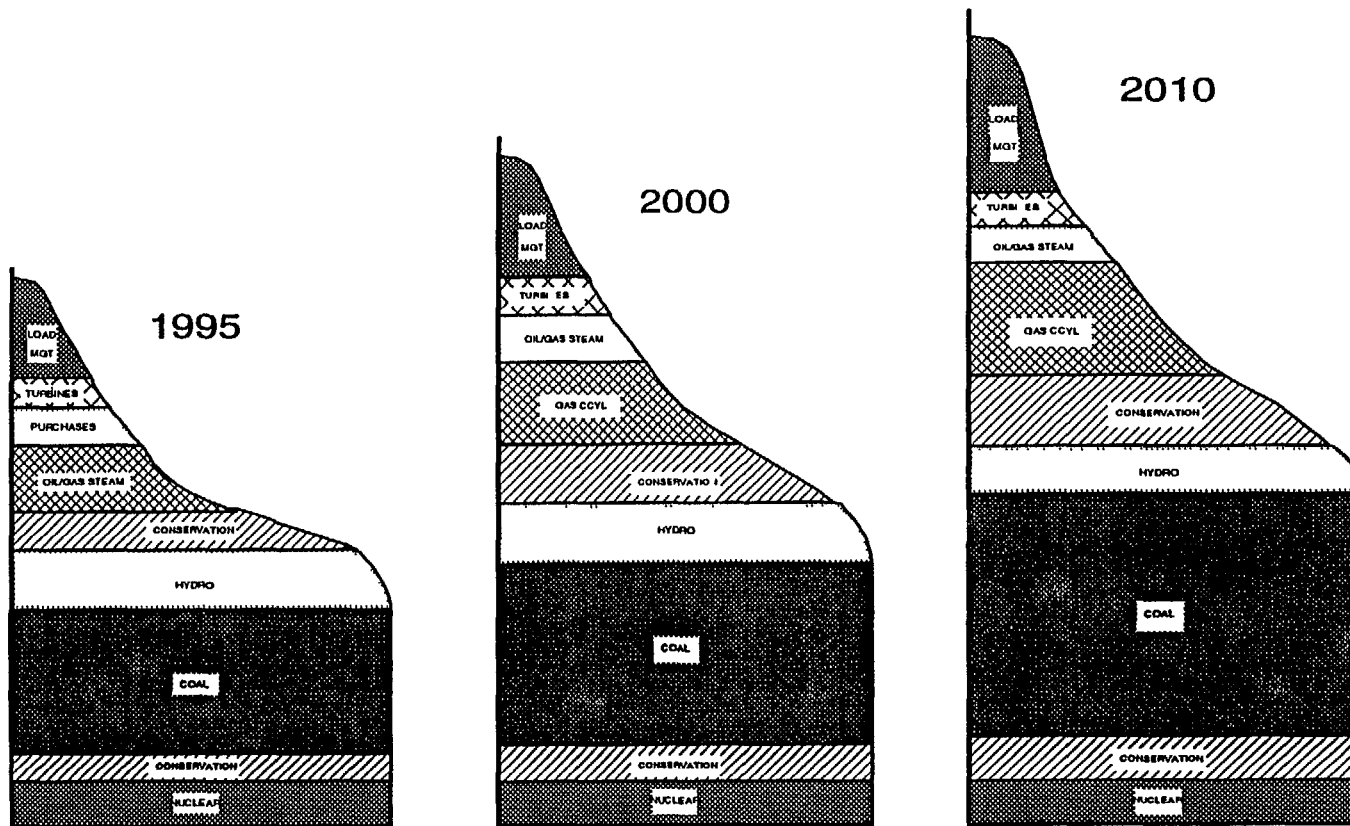
August 17, 1994

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*Overview of the
Integrated Planning Model (IPM)[©]*

⇒ ICF

IPM[®] Provides an Integrated Least-Cost Planning Platform

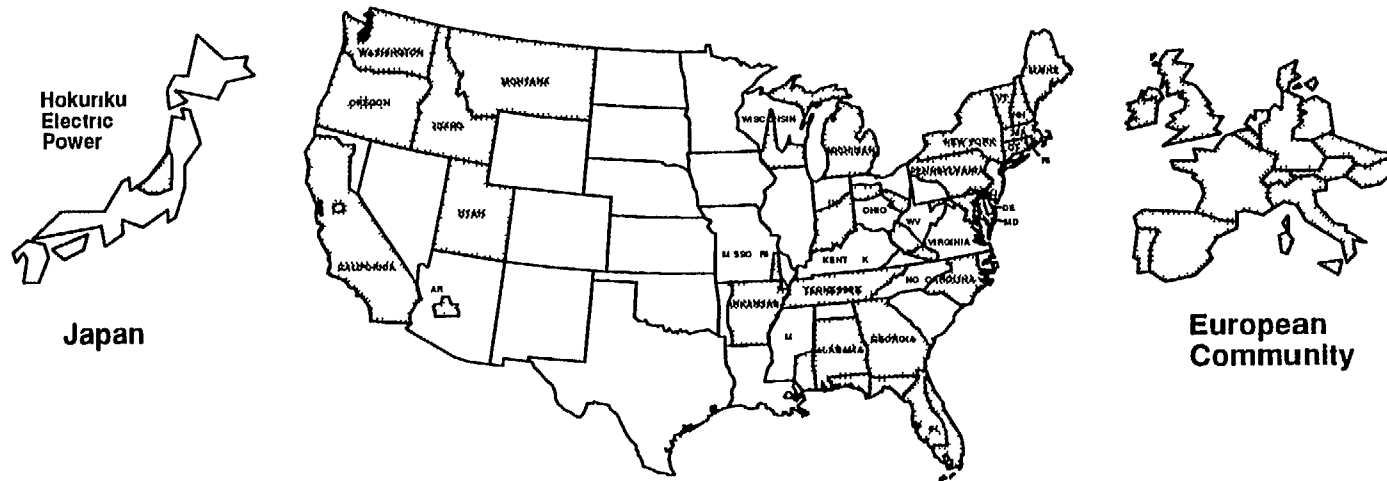


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OVERVIEW

- *ICF's Integrated Planning Model (IPM[©]) is an integrated platform for utility least-cost planning:*
 - *Performs accurate system dispatch and operations simulation*
 - *Develops true least-cost resource plans*
 - *Models conventional utility generating resources, purchase power, renewables, and demand-side management options.*
- *IPM[©] is a dynamic optimization model that accurately evaluates intertemporal tradeoffs.*
- *IPM[©] treats the time-dependent characteristics of demand-side technologies and some renewable technologies within the optimization framework.*
- *IPM[©] accurately evaluates environmental compliance strategies:*
 - *The Acid Rain provisions of the Clean Air Act Amendments*
 - *Potential CO₂ emission reduction policies.*

IPM[©] Has Been Used Extensively Over the Last 12 Years



Utility Systems


American Electric Power
 Arkansas Power and Light
 Carolina Power and Light
 Florida Power and Light
 Hokuriku Electric Power Co
 Pacific Gas and Electric
 Pennsylvania, Jersey Maryland Power Pool
 New England Power Pool
 New York Power Pool
 Southern California Edison
 Tennessee Valley Authority
 Public Service Indiana
 Southern Company
 Wisconsin Power and Light
 Salt River Project
 San Diego Gas and Electric
 PacifiCorp

States/Regions

Pacific Northwest
 Michigan
 Peninsula Florida

National/Multi National

European Community
 Continental U S
 Ecuador
 Morocco

 Modeling Completed

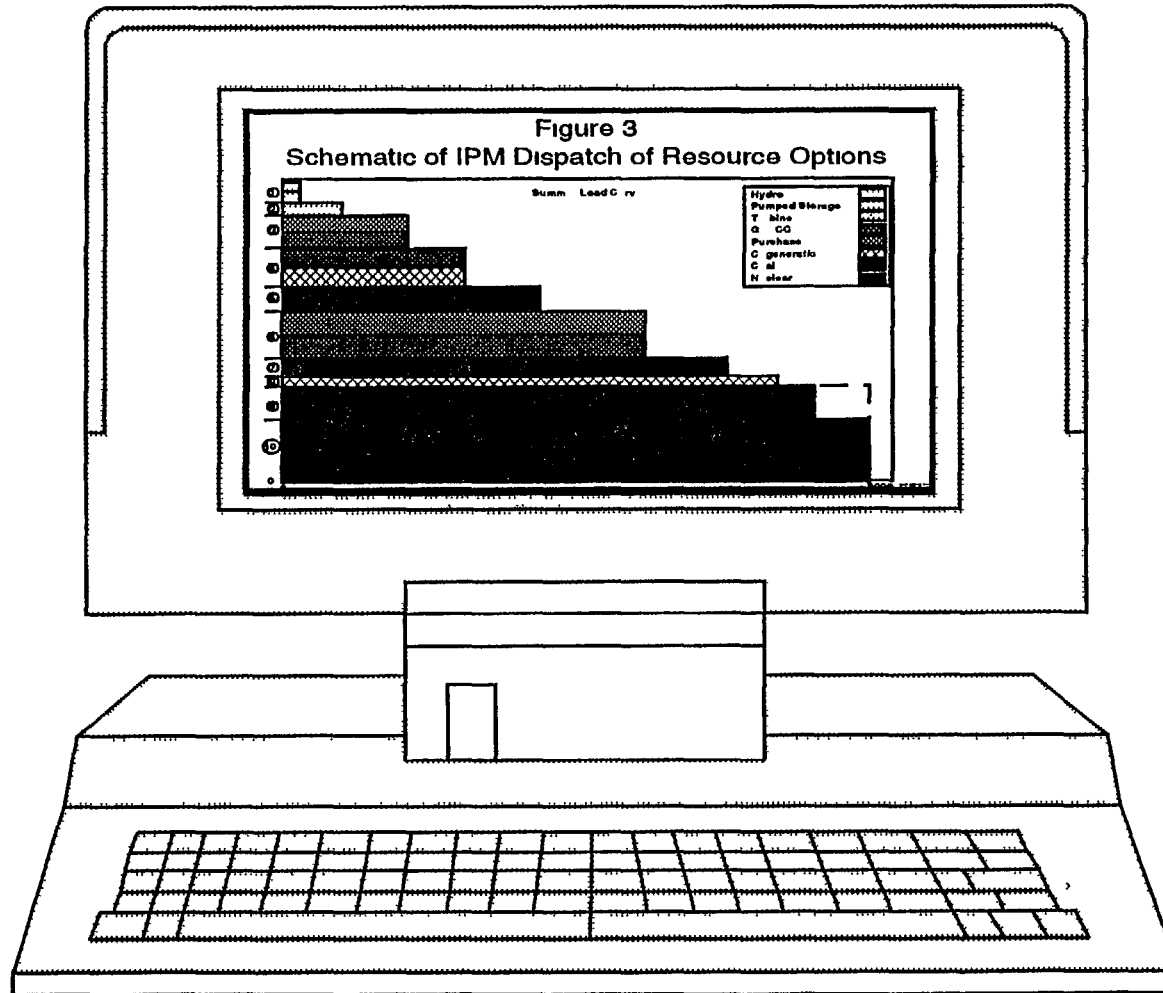
cf/ipmmap2 drw



OVERVIEW

- *ICF has constructed multi-region national versions of IPM[©] for EPA and EEI.*
- *IPM[©] has been used to model many of the major power pools and regions of the country for detailed environmental planning and least-cost resource planning studies.*
- *IPM[©] is being used by U.S. and European utilities and by natural gas companies.*
- *IPM[©] has been under continuous development as ICF's primary utility system planning tool for over 12 years. Over a million dollars have been invested in its design and development.*
- *It was developed in response to client-specific needs that could not readily be addressed by other software systems:*
 - *Simultaneous environmental and resource planning*
 - *Simultaneous optimization of demand- and supply-side options*
 - *Flexibility to model multiple regions with complex interconnections.*

IPM[®] is Accurate, Yet Easy To Use on a PC or a Workstation

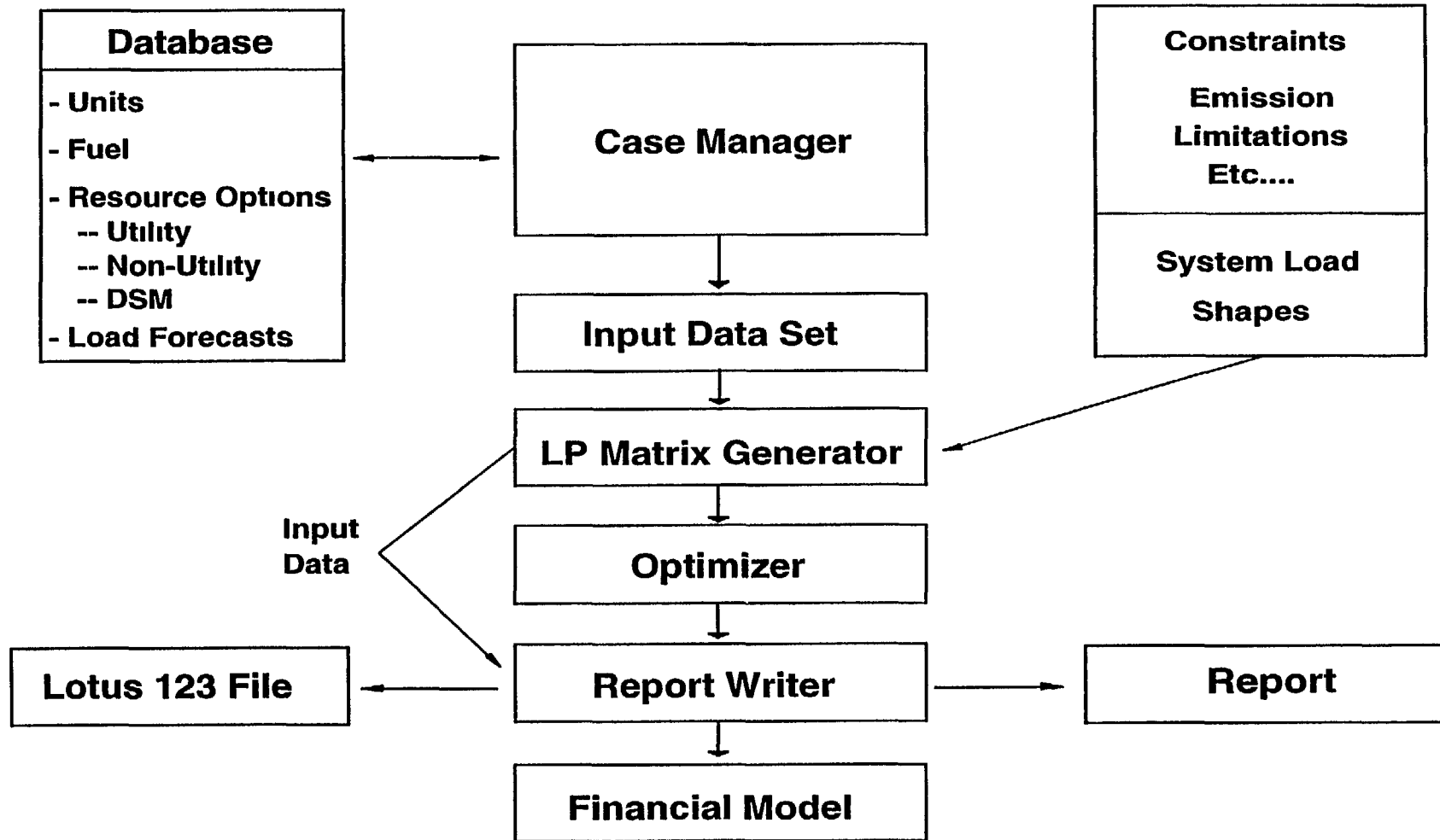


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IPM[©] IS ACCURATE, YET EASY TO USE ON A PC OR A WORKSTATION

- ***Flexible, yet easy to use***
 - *PC, workstation or mainframe versions*
 - *Rapid turn-around time*
 - *PC-based Case and Data Manager facilitates input and scenario development*
 - *Can be tailored to specific power systems.*
- ***Extremely accurate production cost algorithm***
 - *Calibrated against detailed utility dispatch models (e.g., PROMOD III)*
 - *Close conformance with actual generation data.*

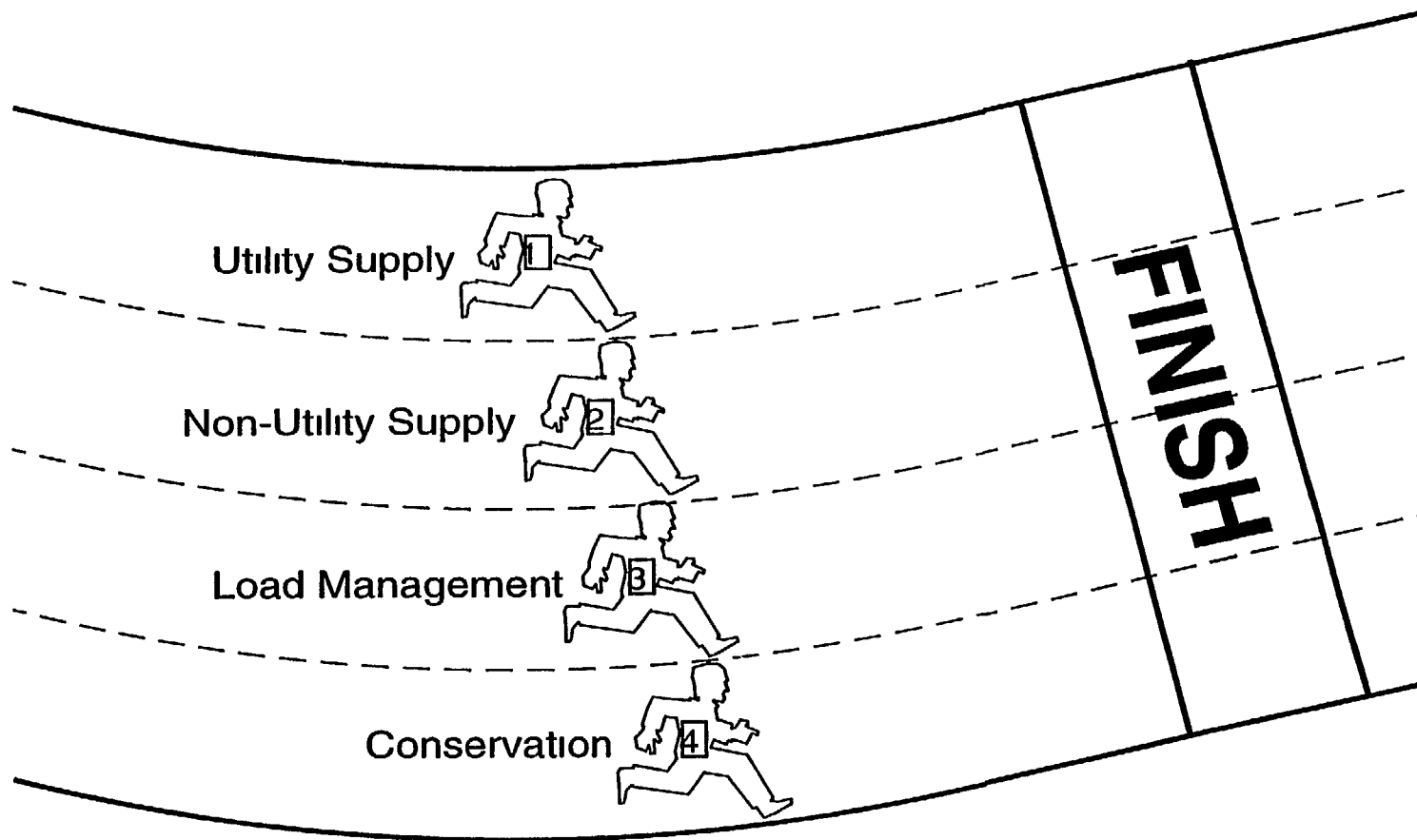
IPM[©] Modules



IPM[©] MODULES

- *IPM[©] is provided with a user-friendly interface, the Case Manager, that makes case and scenario development easy and foolproof.*
- *The Case Manager allows the user to rapidly perform operations such as:*
 - *Changing fuel prices*
 - *Changing unit specifications*
 - *Adding and deleting units or new resources.*
- *The Case Manager produces a data set that is read by a matrix generator program.*
- *The matrix generator is a FORTRAN program that generates a file containing the description of the equations which is then optimized by a commercial linear programming package.*
- *A report writer produces a wide range of reports and Lotus 1-2-3 readable files.*
- *The Electric Utility Financial Model produces a wide range of financial measures.*

All Resource Options Compete On An Equal Footing

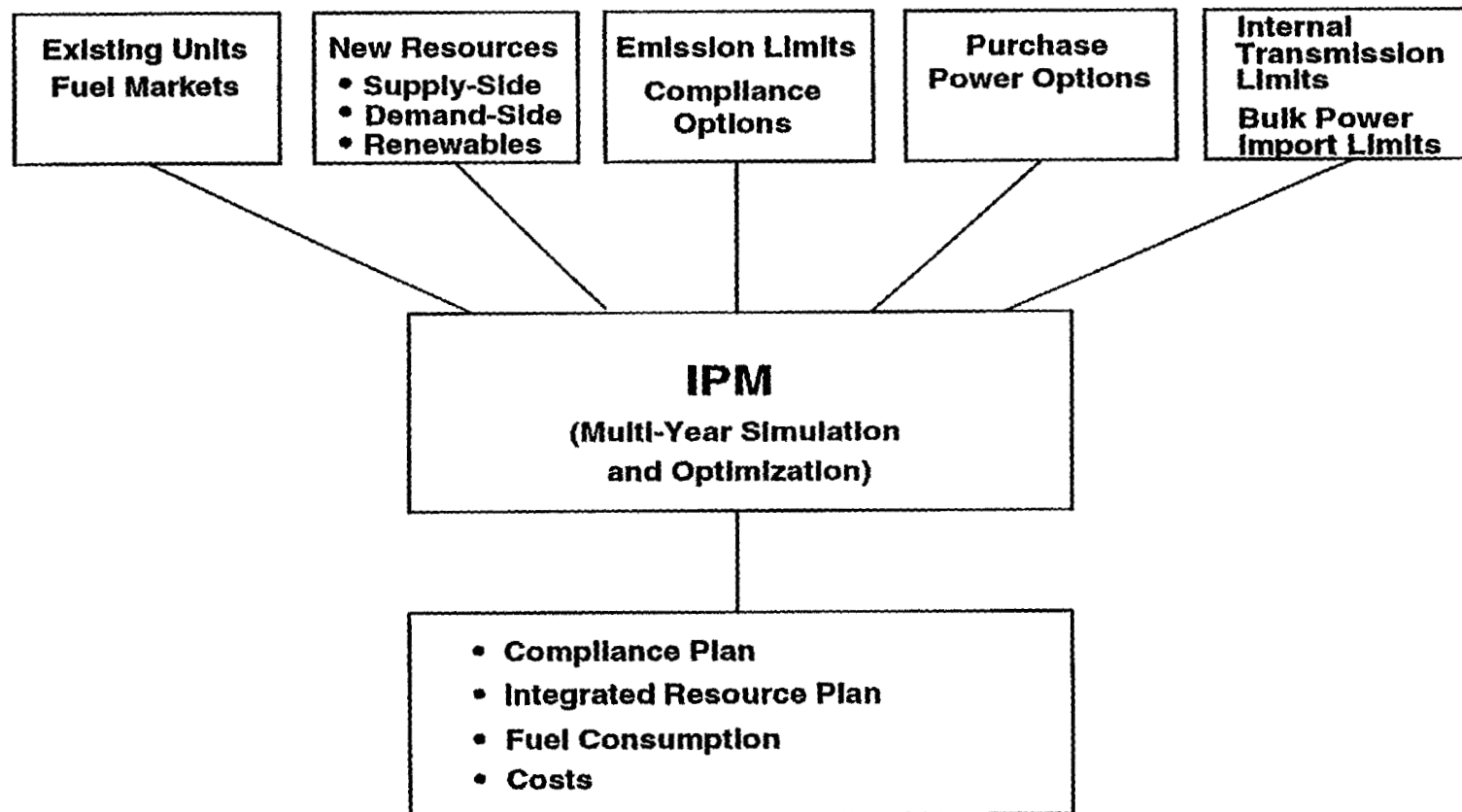


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FEATURES OF IPM[©]

- ***All resources compete on an equal footing.***
 - ***Each resource's unique characteristics are explicitly modeled:***
 - ***Conventional resources are dispatchable and provide capacity equal to their net dependable rating***
 - ***Some renewables are intermittent, providing less than rated capacity***
 - ***DSM options have fixed load alteration patterns and complex relationships between energy and capacity***
 - ***Limits on penetration and timing considerations affect the value of DSM and renewable options.***
 - ***IPM[©] takes these characteristics into account and finds least-cost resource plans over the time frame under consideration.***
- ***IPM[©]'s dynamic feature permits it to evaluate current decisions in the light of expected future resource options, fuel market conditions and regulations.***

Features of IPM[©]



JMW/newbus/ipmfeat

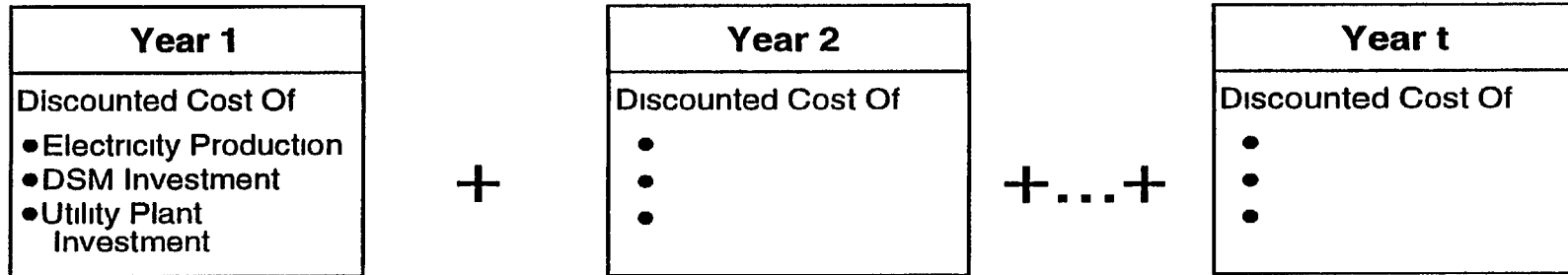


FEATURES OF IPM[©]

■ ***Other IPM[©] features***

- ***Multi-regional power system representation with transmission limitations between regions and joint limitations across sets of regions.***
- ***“Supply curves” for purchase power options can have time of day and seasonal availability and pricing.***
- ***Compliance strategies***
 - ***Scrubbing***
 - ***Fuel switching***
 - ***Co-firing***
 - ***Clean coal technologies.***
- ***Accurate modeling of energy-limited (e.g., hydro) and storage (e.g., pumped hydro or compressed air energy storage).***

IPM[©]'s Algorithm



Subject to

- Operating Constraint (e g , Area Protection, Must Runs)
- Transmission Constraints
- Emission Constraints (e g , SO₂, CO₂)

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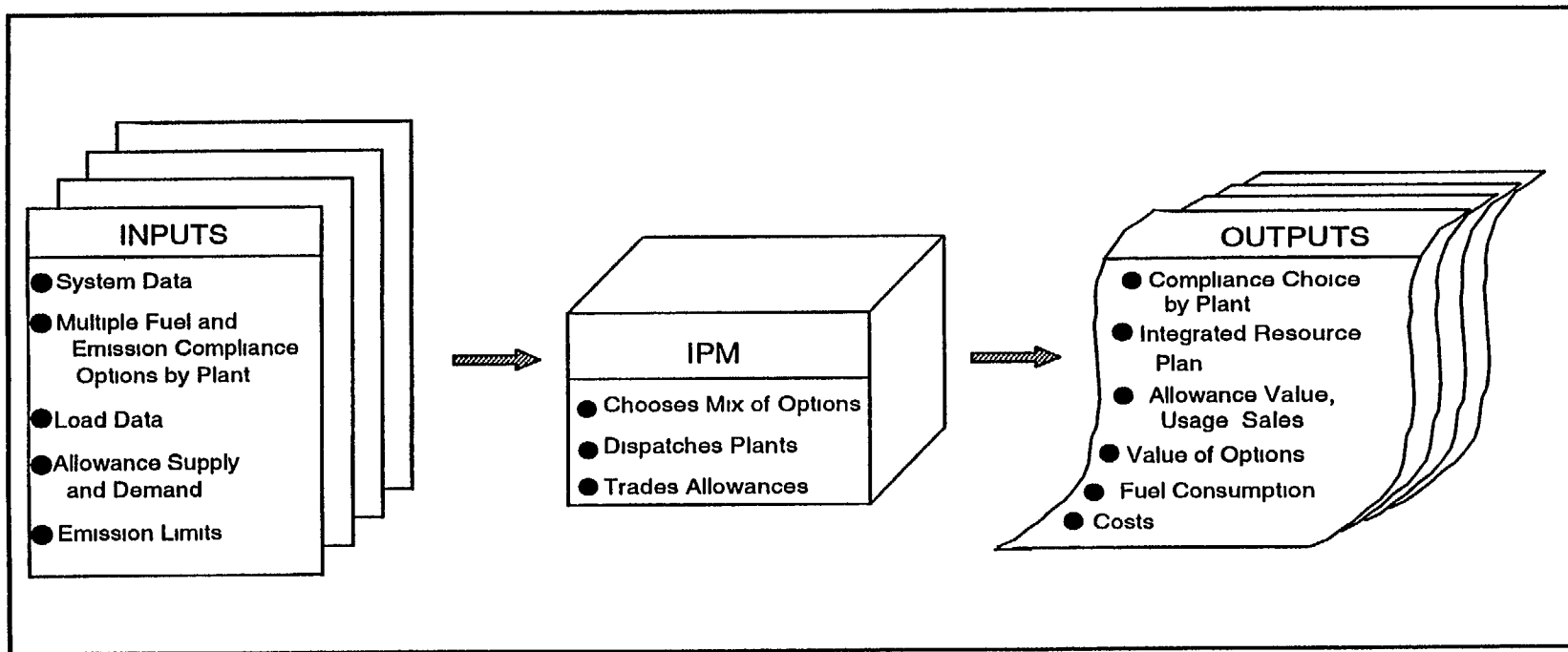
IPM[©]'S ALGORITHM

- ***The IPM[©] is specified in a linear programming format.***
- ***The IPM[©] minimizes the present value of costs over a horizon of up to 70 years. The cost components include:***
 - ***Fuel costs***
 - ***Fixed and variable operating and maintenance costs***
 - ***Capital costs***
 - ***Purchased power costs***
 - ***Cost of demand-side resources (administrative, capital cost).***
- ***Intermittent renewable technologies and demand-side options are treated within the optimization framework as resources with fixed output patterns.***
- ***IPM[©]'s linear programming format permits the optimization to treat explicitly emission limitations, transmission limitations, and unit-specific operating constraints.***



Treatment of Acid Rain and CO₂ Emissions

IPM Can Determine Optimal Compliance Strategies



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TREATMENT OF ACID RAIN AND CO₂ EMISSIONS

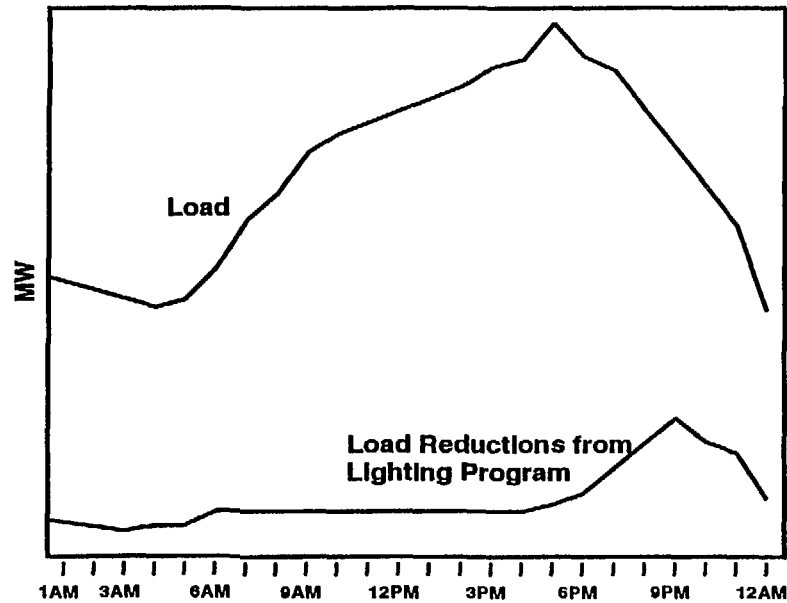
- *IPM[©] models explicit SO₂ and CO₂ limitations, and monitors and reports forecasted levels of these emissions, as well as NO_x, TSP, scrubber sludge and ash.*
- *IPM[©] models all aspects of the Acid Rain provisions of the Clean Air Act Amendments:*
 - *Tonnage caps that vary by year*
 - *Affected units in Phase I and Phase II*
 - *Banking*
 - *Phase I technology credits*
 - *The allowance market.*
- *IPM[©] models all control technologies:*
 - *Retrofit scrubbing*
 - *Retrofit/repowering with clean coal technologies*
 - *Co-firing with gas*
 - *Switching to lower sulfur coals (with ESP upgrade, if required).*
- *Costs (fixed and variable) and changes to unit performance characteristics (rating, forced outage rate, and heat rates) are modeled.*

TREATMENT OF ACID RAIN AND CO₂ EMISSIONS (continued)

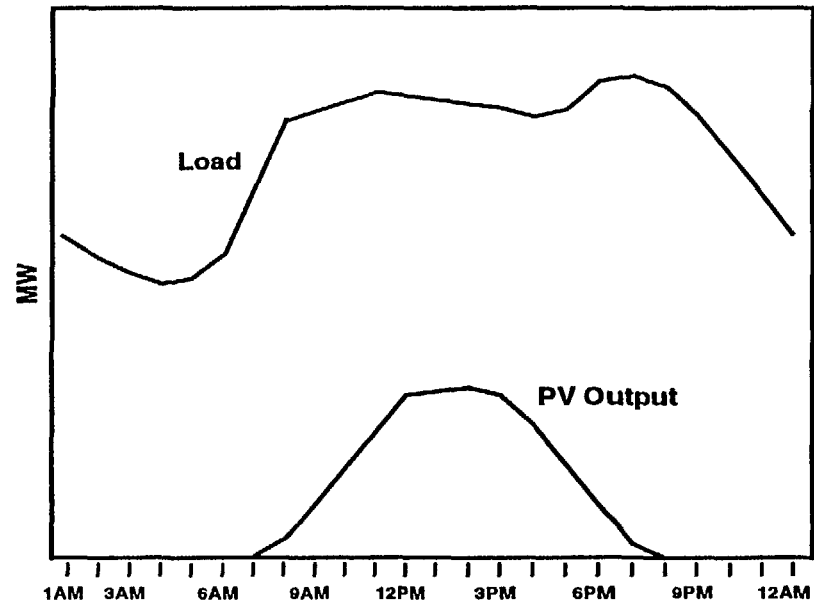
- ***IPM[©] also adjusts unit dispatch in response to SO₂ limits.***
- ***IPM[©] measures the marginal cost of compliance and also the relative value of compliance options.***
- ***IPM[©] provides an additional structure that permits state and local SO₂ regulations to be included, as well as the Clean Air Act provisions.***
- ***IPM[©] can model explicit CO₂ limits and carbon taxes.***

Treatment of DSM and Renewable Technologies

DSM A Typical Summer Weekday Load Shape and the Load Reduction Pattern of a Lighting Program



RENEWABLES: Expected Flat Plate PV Output Compared to Winter Weekday Load



NOTE Load reductions and PV output are not depicted using the same scale as load

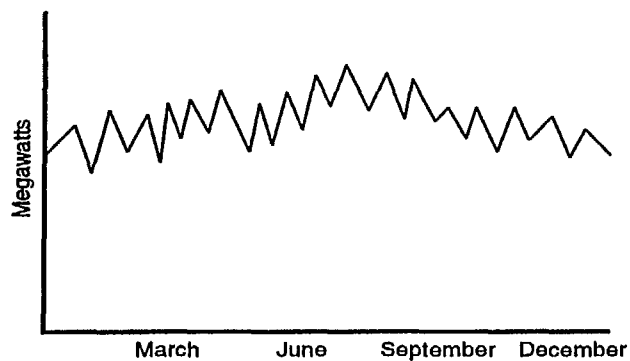
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TREATMENT OF DSM AND RENEWABLE TECHNOLOGIES

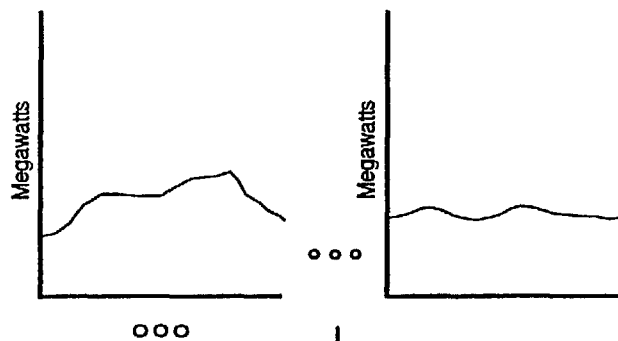
- *DSM and intermittent renewable technologies are treated as fixed patterns of output per installed kw. The optimization algorithms recognize that these technologies provide time-of-day dependent output or load reductions in fixed, seasonal patterns.*
- *IPM[®] recognizes that these technologies usually do not have the same capacity value as dispatchable options.*
- *Demand-side costs include both utility and customer costs.*

DSM Algorithms - Load Alteration Patterns

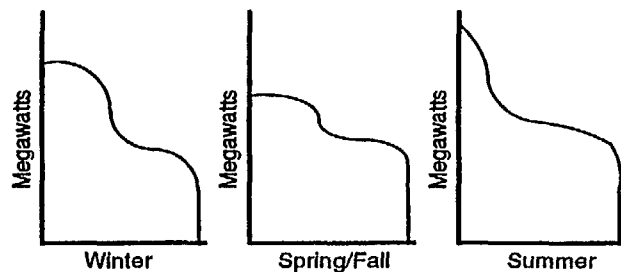
Forecasted Load Shape



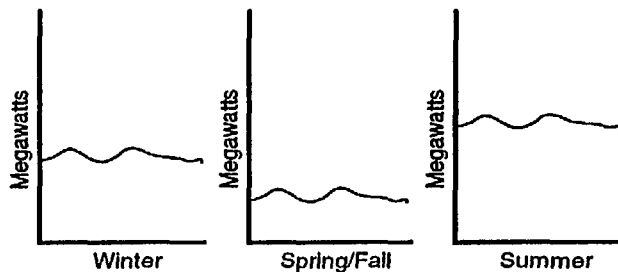
DSM Load Alteration Patterns (Day, Type and Season)



Seasonal Load Duration Curves



Seasonal LDC Alteration Patterns

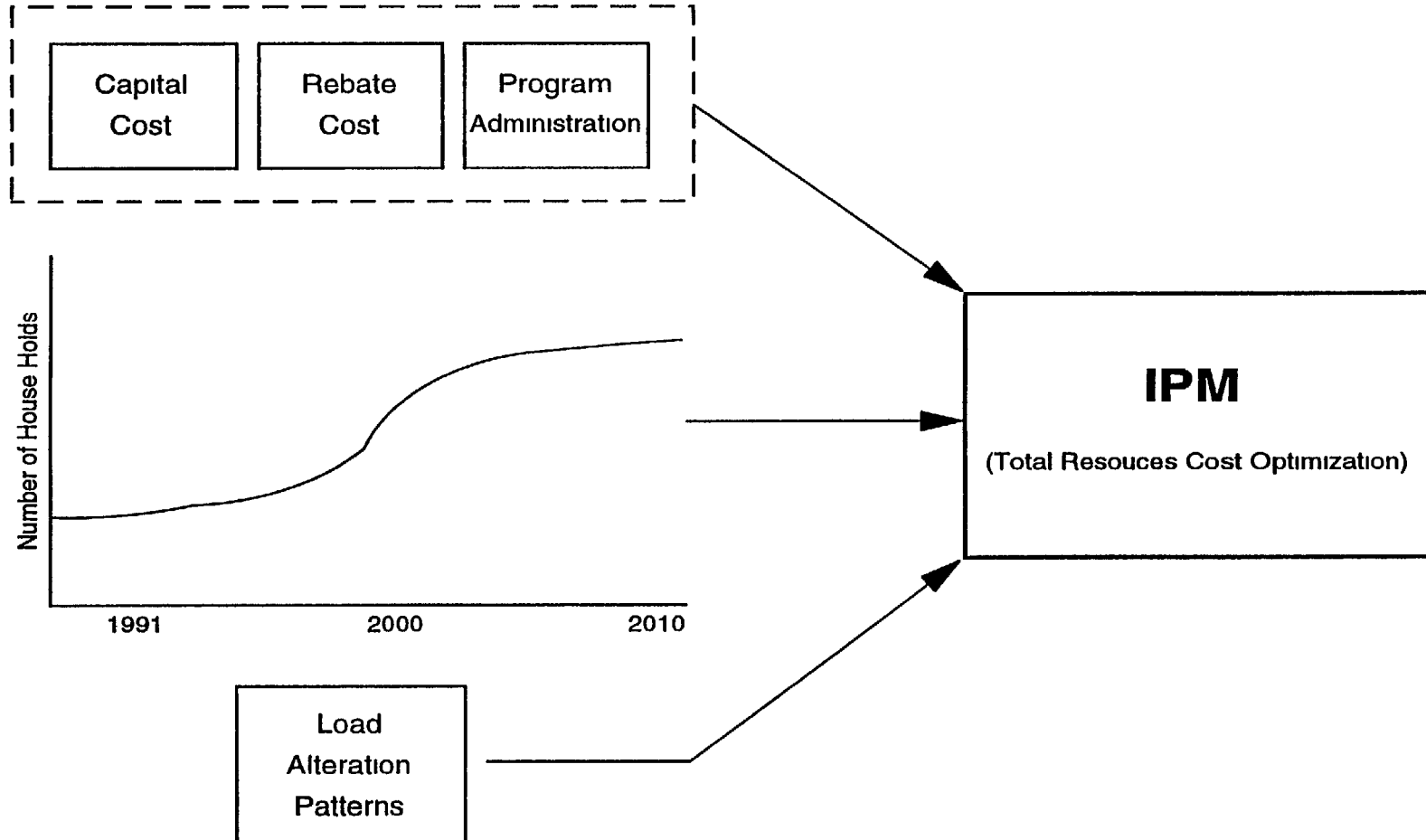


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DSM ALGORITHMS - LOAD ALTERATION PATTERNS

- ***DSM option inputs include seasonal load alteration patterns per “unit” of each option.***
- ***These patterns are required for a weekday, weekend and a peak day by season.***
- ***The “units” specified are flexible:***
 - ***DSM programs can be specified at the device level. This is appropriate for many industrial programs.***
 - ***DSM programs can also be specified in terms of GWH saved.***
- ***IPM[©] starts with forecasted annual load (8760 hours) and creates seasonal load duration shapes. This is the representation of system demand prior to DSM.***
- ***The load alteration patterns are specified as 24-hour load alteration patterns per day type.***
- ***These data are then mapped into a fixed pattern of seasonal DSM patterns.***

DSM Algorithms - Costs and Penetration



DSM ALGORITHMS - COSTS AND PENETRATION

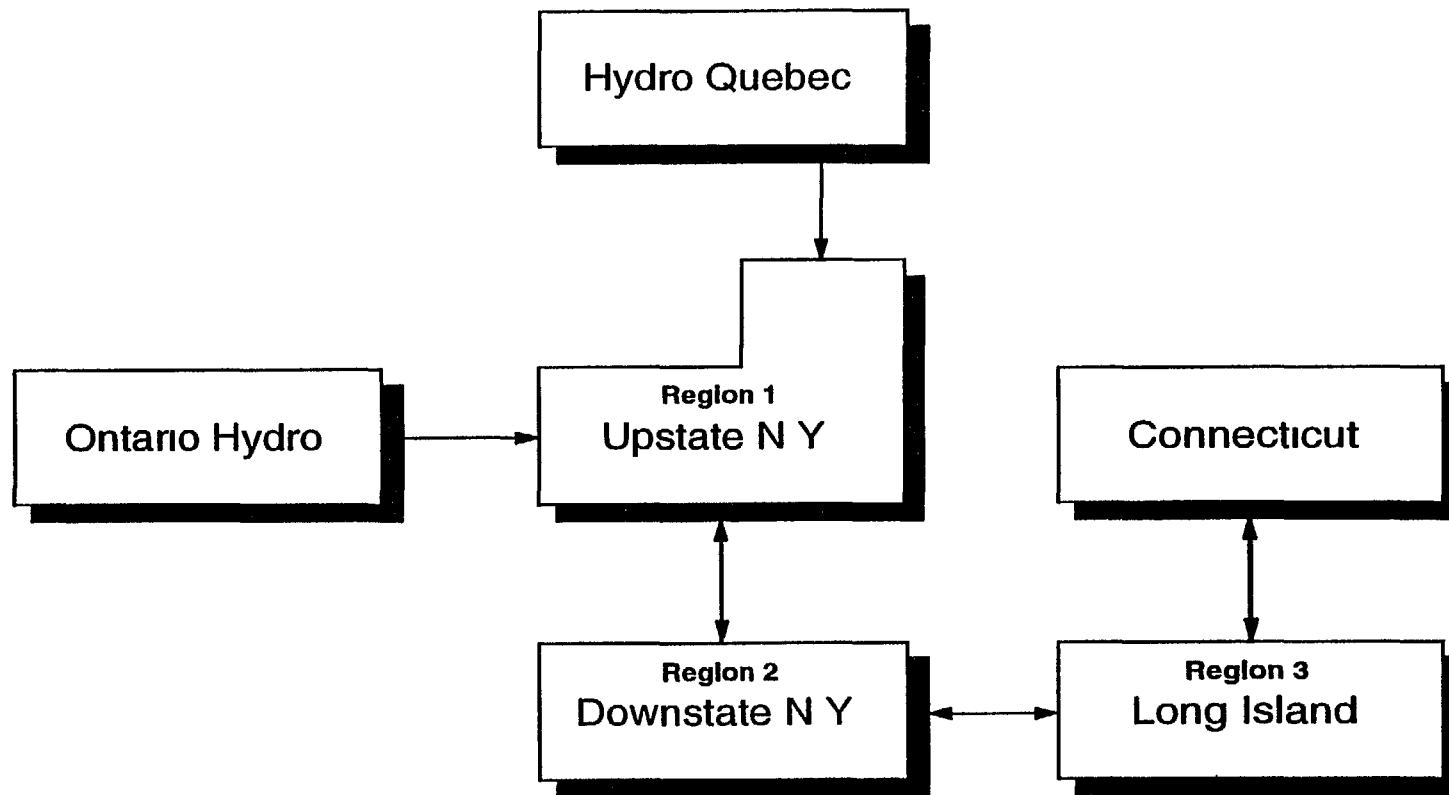
- ***The components of DSM costs are:***
 - ***Capital***
 - ***Rebate***
 - ***Program Administration Costs.***

- ***IPM[©]'s normal mode of operation is to treat the total resource cost of all options. Thus, capital and program administration cost are normally in the linear programming objective function.***

- ***Each DSM option has a penetration rate that specifies the maximum penetration rate for each option. When IPM[©] selects an option, the costs and impacts follow the penetration pattern. Thus, investment in a program must be made in advance of the time the resource is required, and the costs and impacts ramp up over time.***

Treatment of Transmission

IPM's Description of the New York Power Pool

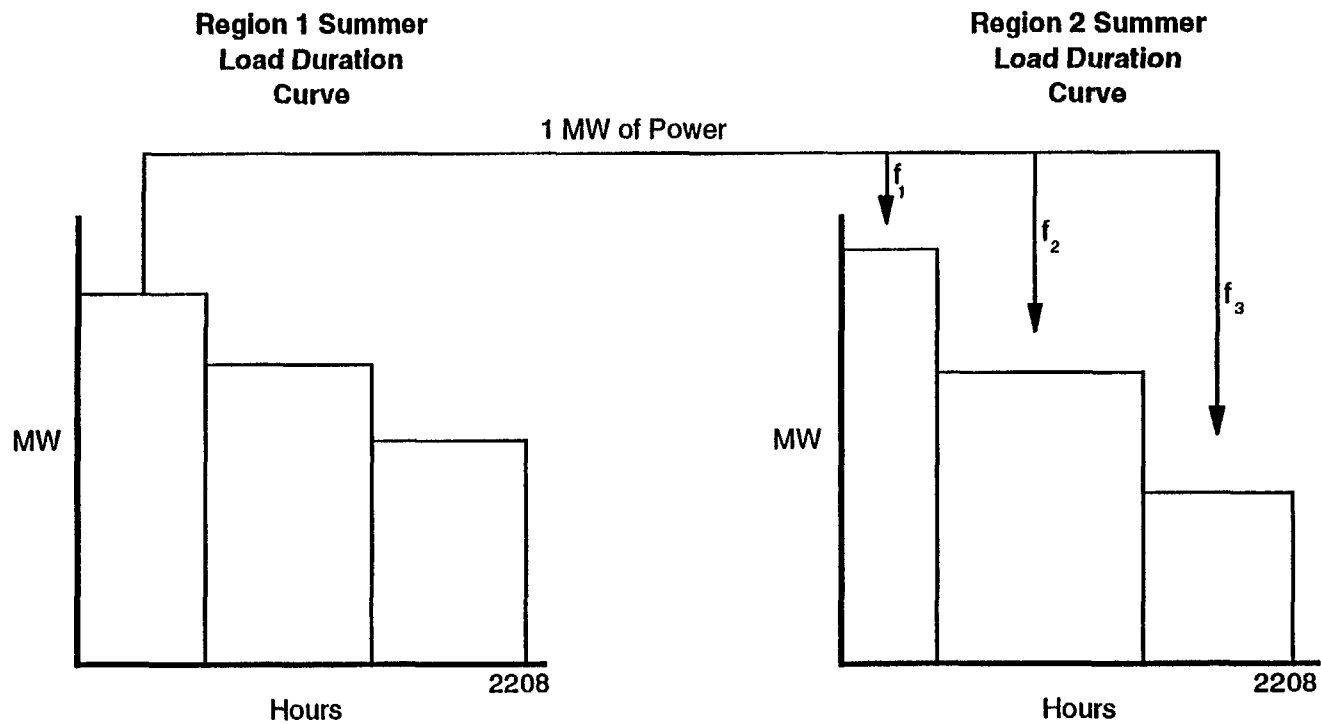


LL/IPM_NYPP

TREATMENT OF TRANSMISSION LIMITATIONS

- ***IPM[©] provides a flexible structure for modeling transmission limitations with a utility system as well as for modeling limitations on power coming into or going out of a utility system.***
- ***The number of “regions” and the transmission line limits between regions are defined by the user and are quite flexible.***
- ***IPM[©] permits joint limits on flows between regions as well as the more complicated limitations that are usually described by a nomogram.***

TREATMENT OF TRANSMISSION



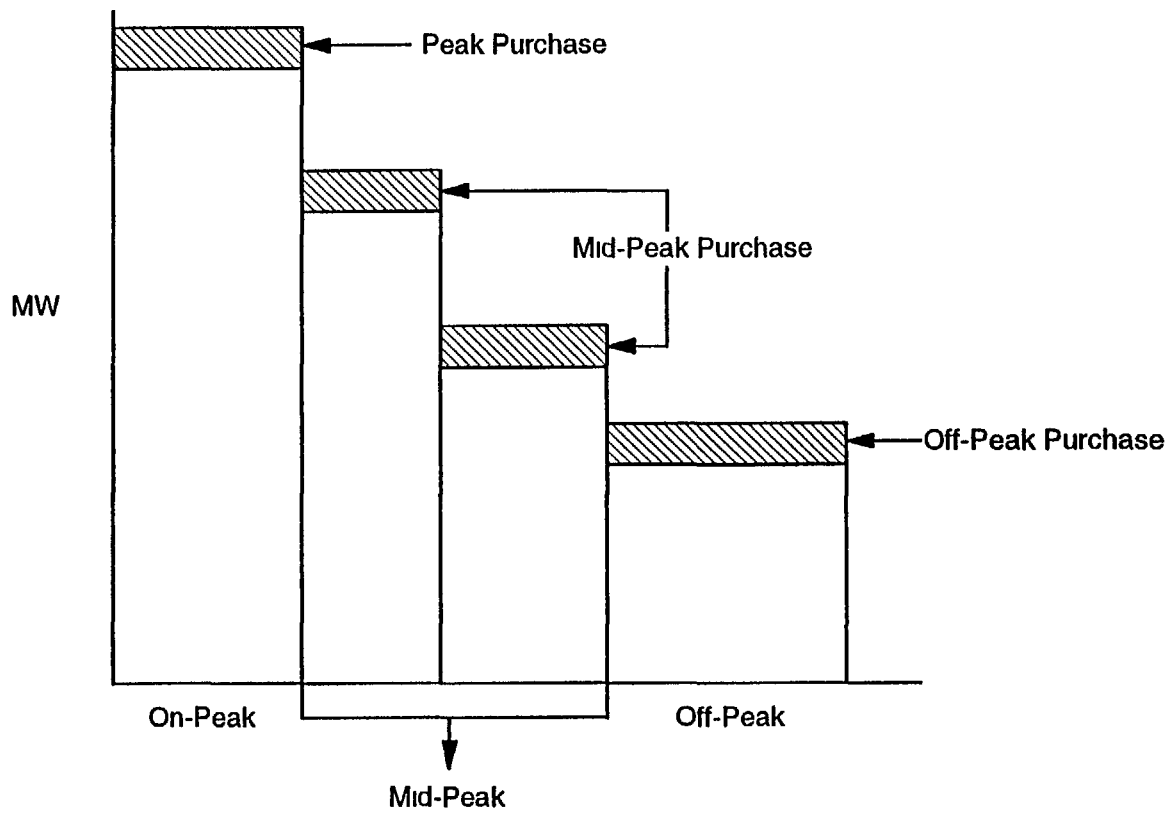
$$f_1 + f_2 + f_3 = 1$$

LL/POWERFLOW

TREATMENT OF TRANSMISSION

- ***IPM[©] keeps track of the hours in each load segment. The hours in each segment and season are used to determine factors that represent the distribution of hours across regions and load segments.***
- ***In the figure above, a MW of transmission from Region 1 is mapped into the three load segments in Region 2 according to the distribution of hours.***

TREATMENT OF PURCHASE POWER AND POWER SALES



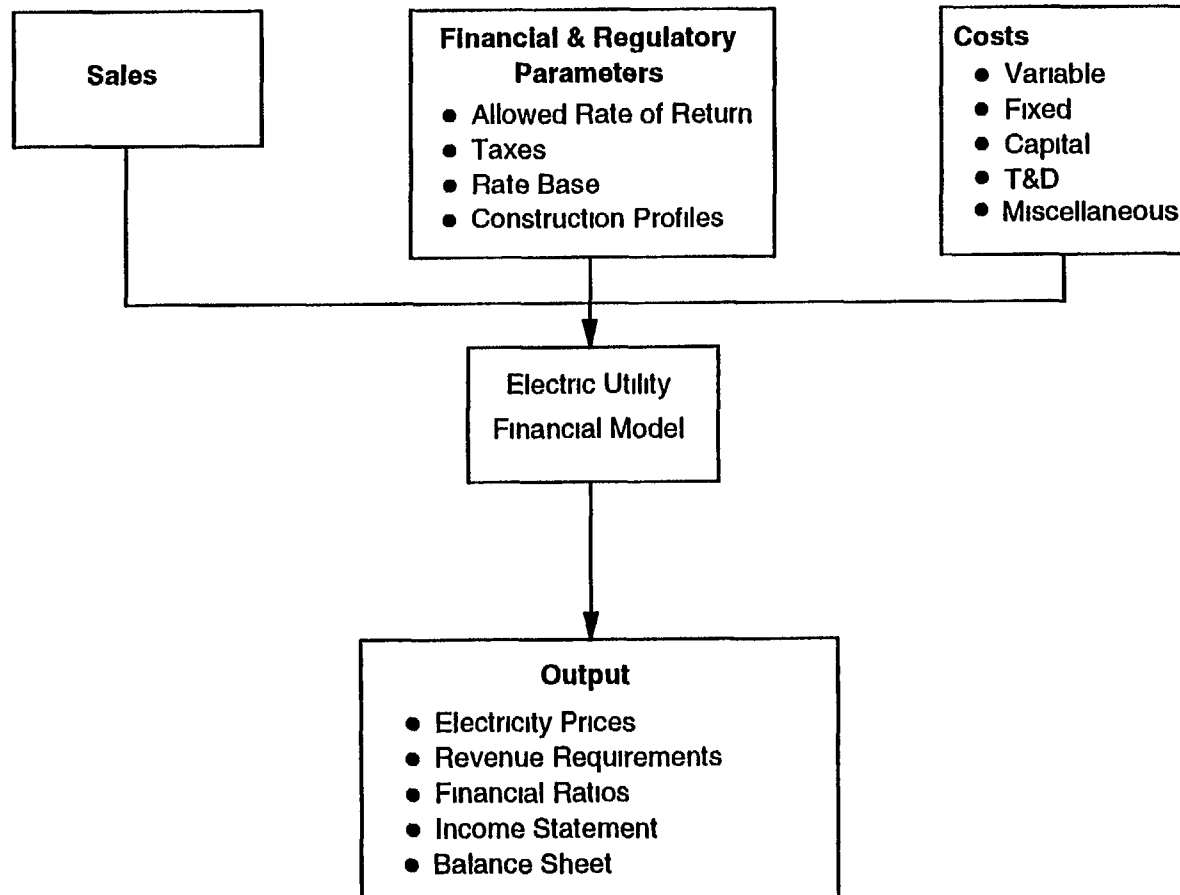
LI/PURCHSAL

TREATMENT OF PURCHASE POWER AND POWER SALES

- *Purchase power can be treated in several ways:*
 - *An ordinary generating unit with, perhaps, an energy limitation.*
 - *A special type of plant that has availability and price characteristics that vary by season and time of day.*
- *The special purchase power structure can be used to model special purchase power contracts and terms, or can be used to build time-of-day dependent supply curves or purchase power.*
- *Power sales can be modeled as fixed load segment specific increases to the load duration curve.*



THE ELECTRIC UTILITY FINANCIAL MODEL (EUFM)



LL/EUFM

THE ELECTRIC UTILITY FINANCIAL MODEL

- *EUFM was first developed for EIA in 1981. Since then, it has since been enhanced by ICF Resources and integrated within the IPM[©] framework.*
- *EUFM can be used as part of IPM[©] or in a stand-alone mode. IPM[©] provides generating unit costs, purchase power costs, and DSM costs.*
- *EUFM runs quickly on a PC: 10-15 seconds on a 386 machine.*
- *EUFM could be structured to run monthly in conjunction with monthly IPM[©] runs.*

THE ELECTRIC UTILITY FINANCIAL MODEL

DATA REQUIREMENTS

From IPM[®]

- ***Sales***
- ***Fuel Costs***
- ***Variable O&M***
- ***Fixed O&M***
- ***Capital Expenditures***
- ***DSM Costs***
- ***DSM T&D Benefits***
- ***T&D for New Plants***
- ***Price and Level of Economy Transactions***

Financial/Regulatory Database

- ***Allowed Rate of Return***
- ***Tax Rates***
- ***Depreciation Schedules***
- ***Debt/Equity Structures***
- ***Debt/Equity Rates of Return***
- ***CWIP and AFUDC***
- ***Inflation***
- ***Book and Tax Value of Existing Capital Stock***
- ***Construction Profiles***
- ***Miscellaneous Expenditures***



THE ELECTRIC UTILITY FINANCIAL MODEL

- ***EUFM is totally data driven and does not require code modifications in response to changes in the regulatory and financial environment.***
- ***The database is fairly small and does not ordinarily require major updates unless tax laws or regulatory policy changes.***