Overview:

# Examples of Energy Forecasting

Presented at:

## 20th Meeting of the CAREC Energy Sector Coordinating Committee

Kuala Lumpur, Malaysia
7-10 September 2015

**Bruce Hamilton**
Energy and Environmental Systems Engineer

# Topics of Discussion

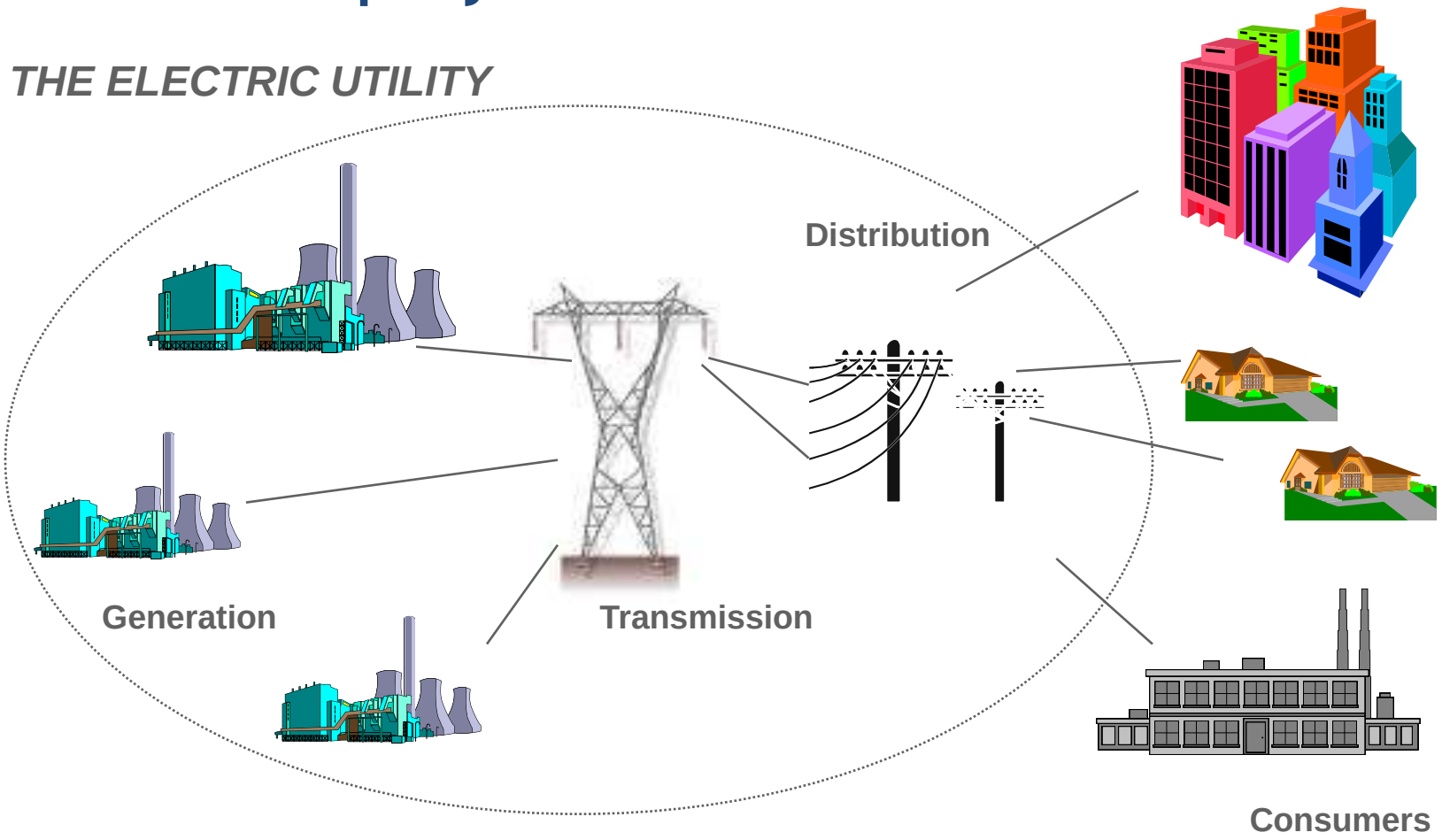
1. Integrated Electricity System Planning Tools
2. Generation Expansion Planning
3. Regional Energy Exchange and Electricity Markets
4. Transmission Investment Evaluation
5. Hydro-Thermal Asset Optimization

# Creating Strong Intertie Connections with Neighboring Utility Systems Has Numerous Benefits

- More efficient dispatch of generating units
- More economical electricity generation
- Higher reliability of system operation
- Lower spinning reserve requirements
- Better management of hydropower plants & reservoirs
- Lower capacity expansion costs

**New energy forecasting tools are needed to analyze issues related to regional interconnections**

# The Traditional System Is a Vertically Integrated Electric Company

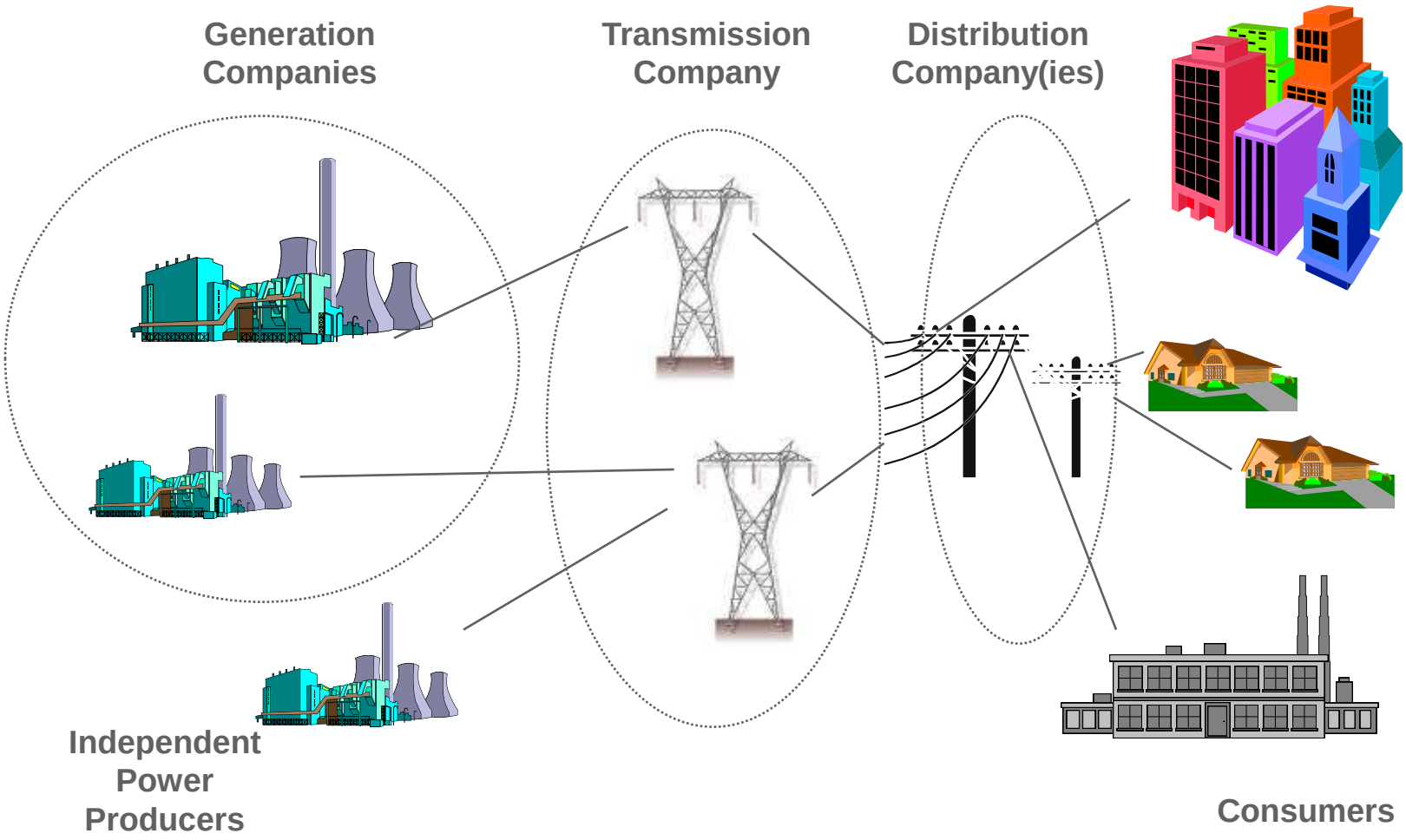



***The utility may be government-owned or privately owned***

# The Analysis of System Operation and Expansion Is Straightforward

- Unit dispatch is modeled based on lowest variable cost
- Reliability requirements can be incorporated as constraints
- Expansion planning based on system-wide least cost discounted present value

# Restructured Electricity System

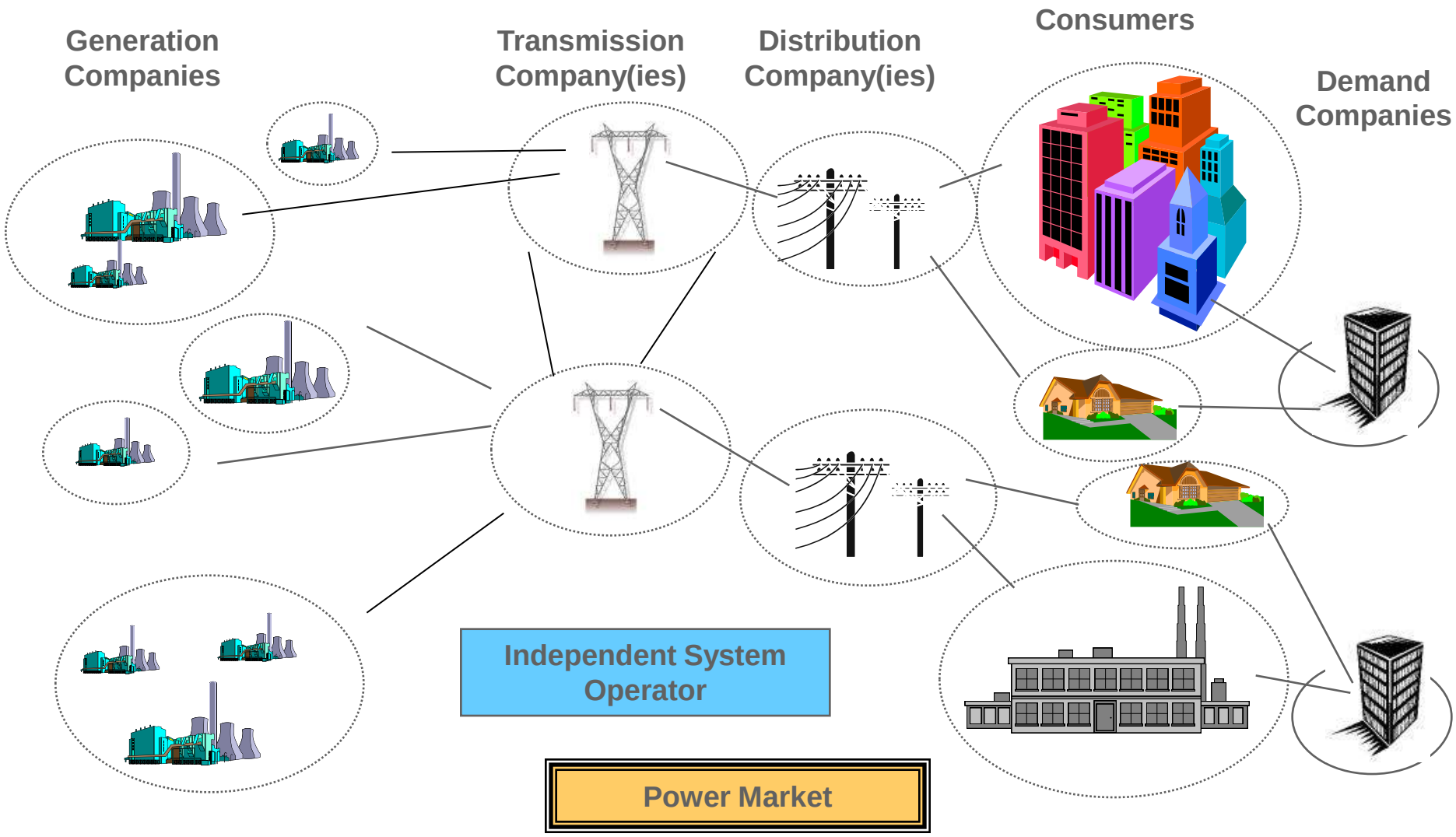



***The companies may be government-owned or privately owned***

# The Analysis Process Is More Complicated

- Each company's financial status is important
- Generation expansion is evaluated by individual unit financial parameters (e.g., ROI, payback period)
- Generators can be a government enterprise, part of a large generation company, or an IPP

# Fully Implement Electricity Market



# The Analysis Is Also Much More Complex

- Unit dispatch is based on power market rules and can include:
  - Long-term contracts
  - Short-term contracts
  - Pool (spot) market
- Access to transmission capacity is a key element
- Capacity expansion is based on individual company business strategies

# Integrated Electricity System Planning Tools


- Prepare optimum generation expansion plan


- Optimize system taking into account power plants, hydro cascades, IPP agreements, power and energy transaction opportunities, and limitations of transmission resources
- Calculate hourly locational electricity prices

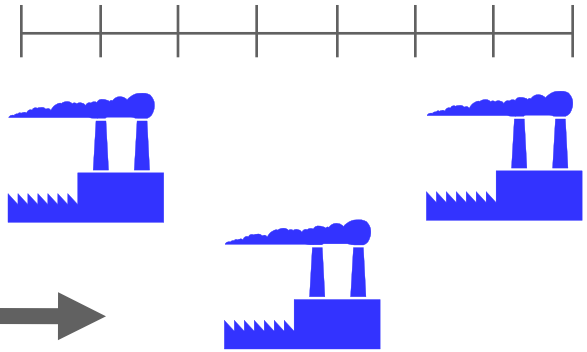

- Power Flow Analysis
- Fault Analysis
- Dynamic Simulations

# WASP Methodology

## INPUT

- Load forecast
- Existing system
- Candidates
- Constraints:
  - Reliability
  - Implementation
  - Fuel
  - *Generation*
  - *Emissions*


## OUTPUT



- Build schedule
- Generation
- Costs
- Fuel consumption
- *Emissions*

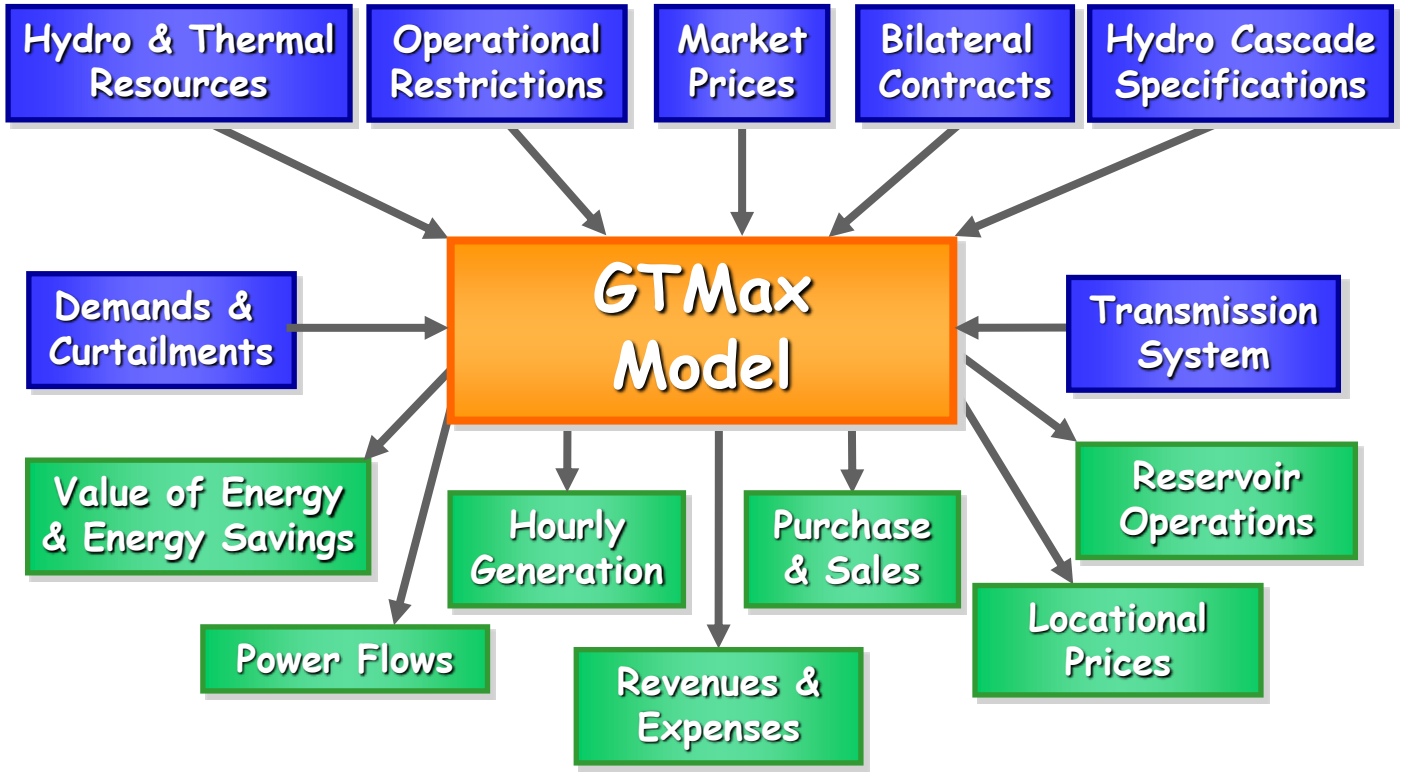
WASP Determines the Generating System Expansion Plan that Meets Demand at Minimum Cost; Cost = capital+O&M+fuel+unserved energy

**IAEA distributes WASP for use in over 80 countries and 15 international agencies**

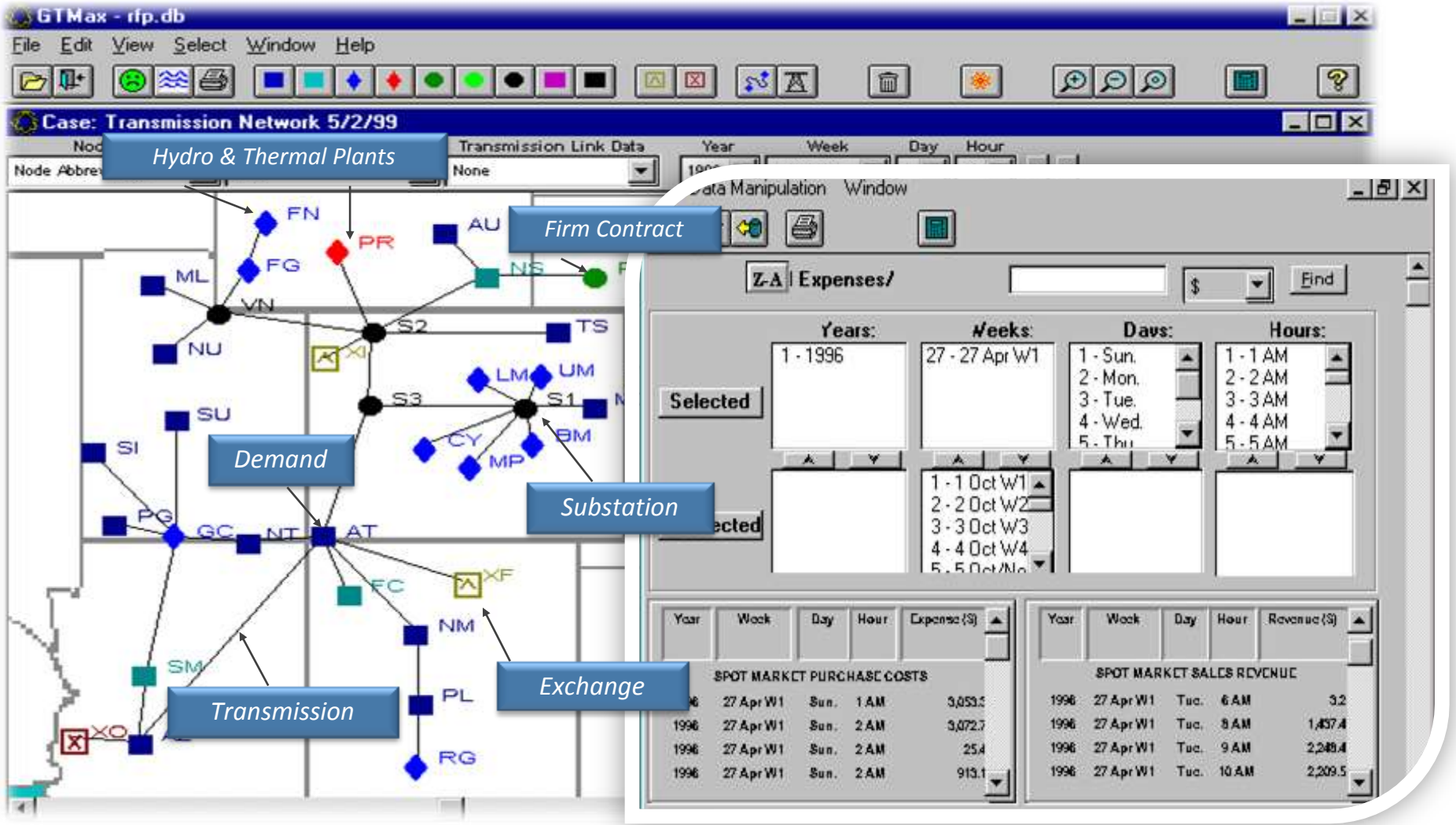
# Generation and Transmission Maximization Program (GTMax)

GTMax optimizes operation of the generation and transmission system and analyzes regional interconnections

Hourly simulation model with hydropower focus



# GTMax Uses a Network Representation of a Power System




**Users specify the characteristics & capabilities of each component**

# Integrated Planning Tool Results must be presented in a Format Suitable for Decision Making

| GOALS | Key Performance Indicators | Units | Scenario 1 | Scenario 2 | Scenario 3 |
|---|---|---|---|---|---|
| Sustainable | GHG emissions | M tons | 61,000 | 57,000 | 45,100 |
| | Renewable energy in system | % | 0 | 20% | 15% |
| Reliable | Security of Supply | Qualitative | Medium | Moderate | High |
| | Reserve Margin | % | 12% | 30% | 14% |
| | System Stability | CAIDI & SAIFI | Medium | Low | High |
| Competitive | Energy price | $/MWh | 122 | 165 | 110 |
| | Fuel price risk | Qualitative | Medium | Moderate | Low |
| | Export potential | MWh | Medium | Moderate | High |
| | Foreign bill | Qualitative | Moderate | High | Low |
| | Employment | Millions | 1.4 | 1.1 | 1.7 |
| Achievable | Ease of implementation | Qualitative | Difficult | Moderate | Very Difficult |
| | Associated Risk | Qualitative | Moderate | High | Medium |

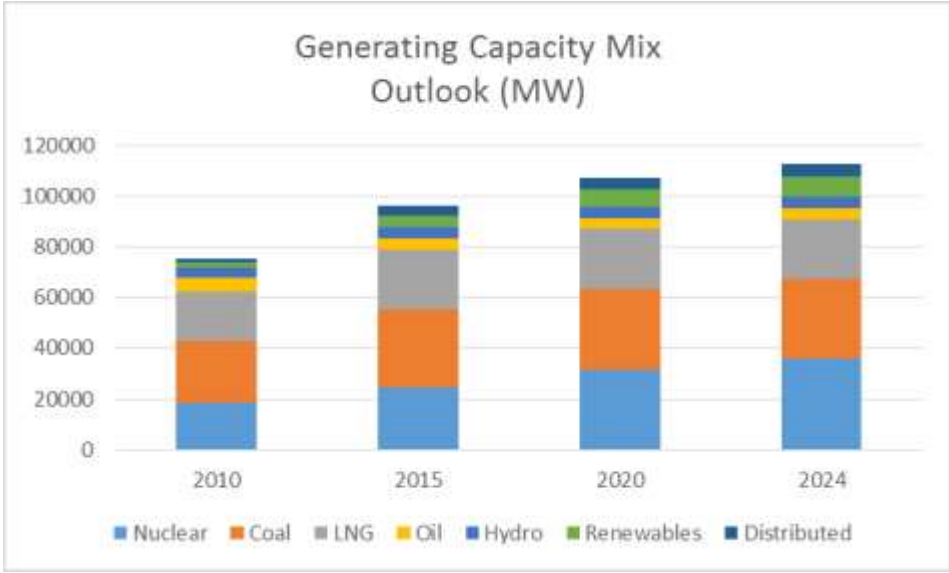
Best 2nd best Worst

# Topics of Discussion

1. Integrated Electricity System Planning Tools
2. Generation Expansion Planning
3. Regional Energy Exchange and Electricity Markets
4. Transmission Investment Evaluation
5. Hydro-Thermal Asset Optimization

# WASP used to Prepare Korea Long Term Generation Plan

- Analysis conducted by the Korea Power Exchange (KPX)
- KPX is required to prepare a Basic Plan for Long-term Electricity Supply and Demand (BPE) every two years
- The BPE stipulates electricity policy directions on supply and demand, long-term electricity outlook, construction plans, DSM, etc.
- Policy directions Direction of the BPE:
  - Establish economic and eco-friendly generation mix
  - Taking into consideration RPS targets, resource potential, construction intents of Gencos, etc.

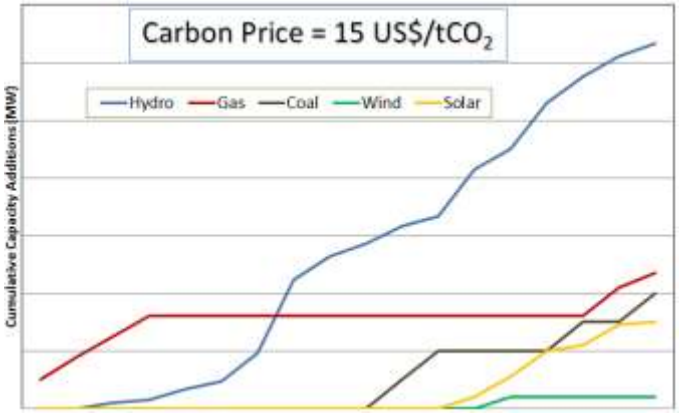



# WASP used to Determine Least Cost Power Expansion Plan in Myanmar

- Analysis conducted for government agencies: National Energy Management Committee, Ministry of Energy (MOE), and Ministry of Electric Power (MOEP)
- Studies sponsored by ADB and JICA
- Studies conducted by Adica and Newjec

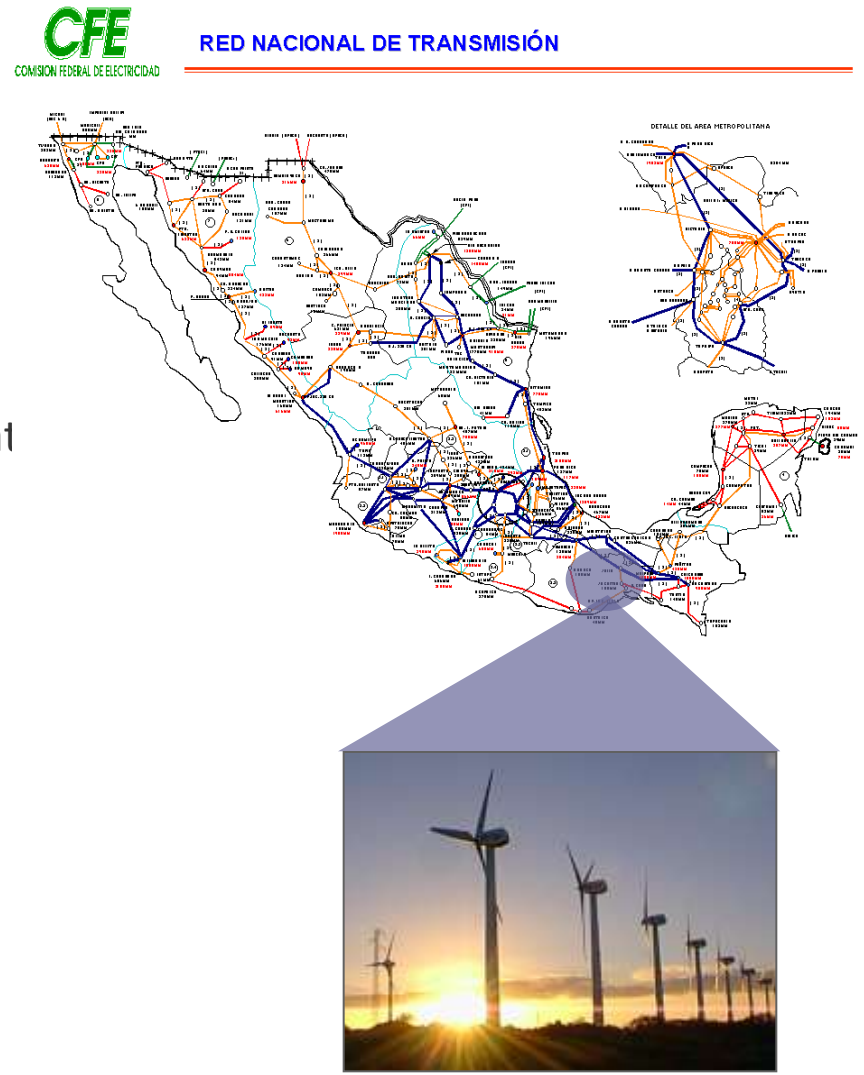
- WASP model results are consistent with historical statistics on system operations
- Compare Least Cost results with environmental scenarios

| | WASP RESULTS | | | | ACTUAL STATISTICS | | |
|---|---|---|---|---|---|---|---|
| Period | Hydro | Gas | Coal | Month | Hydro | Gas | Coal |
| 1 | 655,000 | 148,000 | 20,400 | Jan | 630,040 | 225,422 | 24,774 |
| 2 | 596,000 | 243,200 | 20,400 | Feb | 594,998 | 210,256 | 13,114 |
| 3 | 648,000 | 282,500 | 20,400 | Mar | 659,482 | 278,571 | 16,744 |
| 4 | 652,000 | 292,300 | 20,400 | Apr | 685,622 | 208,497 | 16,643 |
| 5 | 606,000 | 359,100 | 20,400 | May | 629,492 | 278,542 | 17,486 |
| 6 | 612,000 | 337,400 | 20,400 | Jun | 626,444 | 285,619 | 16,018 |
| 7 | 668,000 | 286,500 | - | Jul | 690,901 | 294,447 | 14,254 |
| 8 | 780,000 | 169,800 | 20,400 | Aug | 812,727 | 232,556 | 18,587 |
| 9 | 763,000 | 215,500 | 20,400 | Sep | 825,385 | 203,714 | 11,032 |
| 10 | 814,000 | 173,200 | 20,400 | Oct | 870,771 | 211,691 | - |
| 11 | 796,000 | 163,300 | 20,400 | Nov | 829,618 | 223,133 | - |
| 12 | 694,000 | 242,100 | 20,400 | Dec | 734,607 | 278,125 | 12,393 |
| Total | 8,284,000 | 2,912,900 | 224,400 | Total | 8,590,086 | 2,930,573 | 161,045 |
| | 11,421,300 | | | | 11,681,704 | | |

# WASP used to Determine the Economics of a Wind-farm

- Analysis conducted for the Mexican Power Company (CFE)
- Study sponsored by World Bank-GEF
- GEF considers to cover the incremental costs to stimulate development of 100 MW wind capacity
- Objective of analysis was to determine the incremental cost (capacity and energy) to CFE that GEF would cover
- WASP-IV was used to estimate the long-term benefits of wind energy over the lifetime of the wind farm:
  - Wind energy credits
  - Wind capacity credits
  - Wind carbon credits

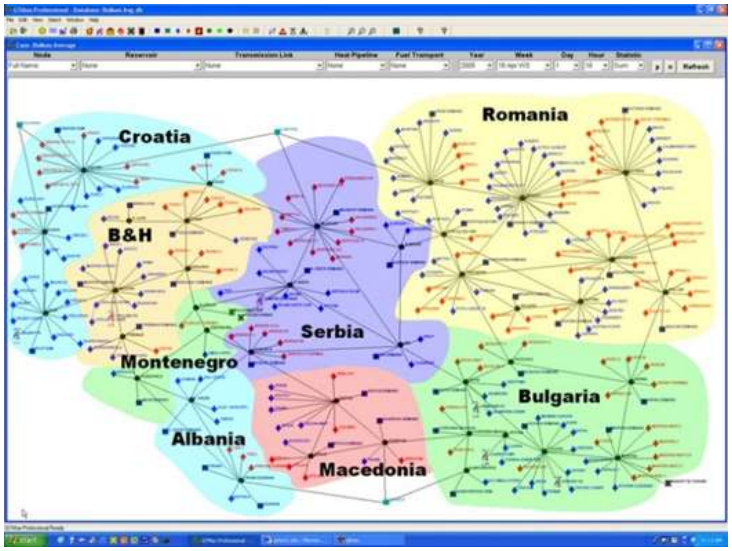


# Topics of Discussion

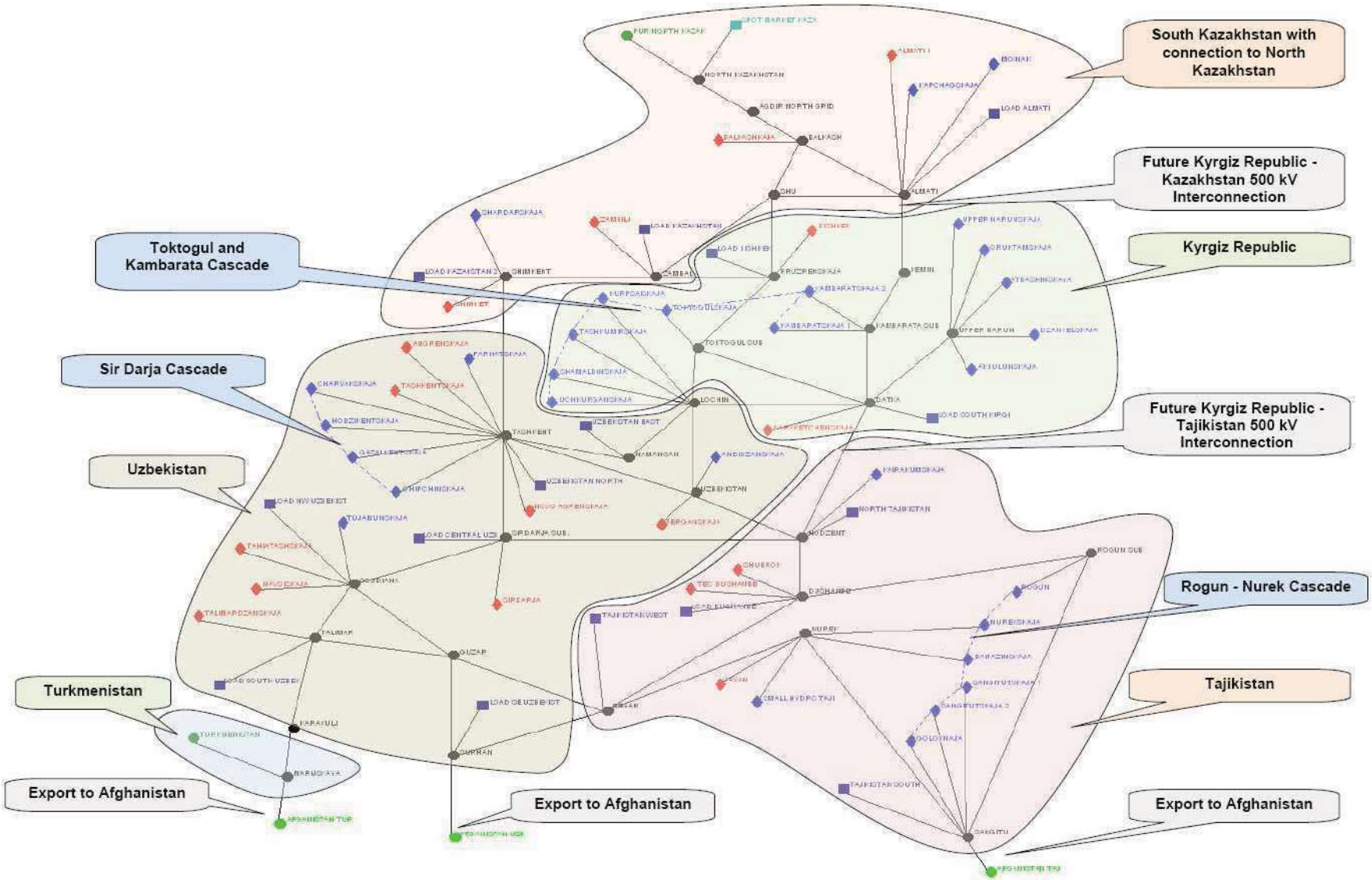
1. Integrated Electricity System Planning Tools
2. Generation Expansion Planning
3. Regional Energy Exchange and Electricity Markets
4. Transmission Investment Evaluation
5. Hydro-Thermal Asset Optimization

# GTMax used to Analyze Regional Energy Exchange and Electricity Markets

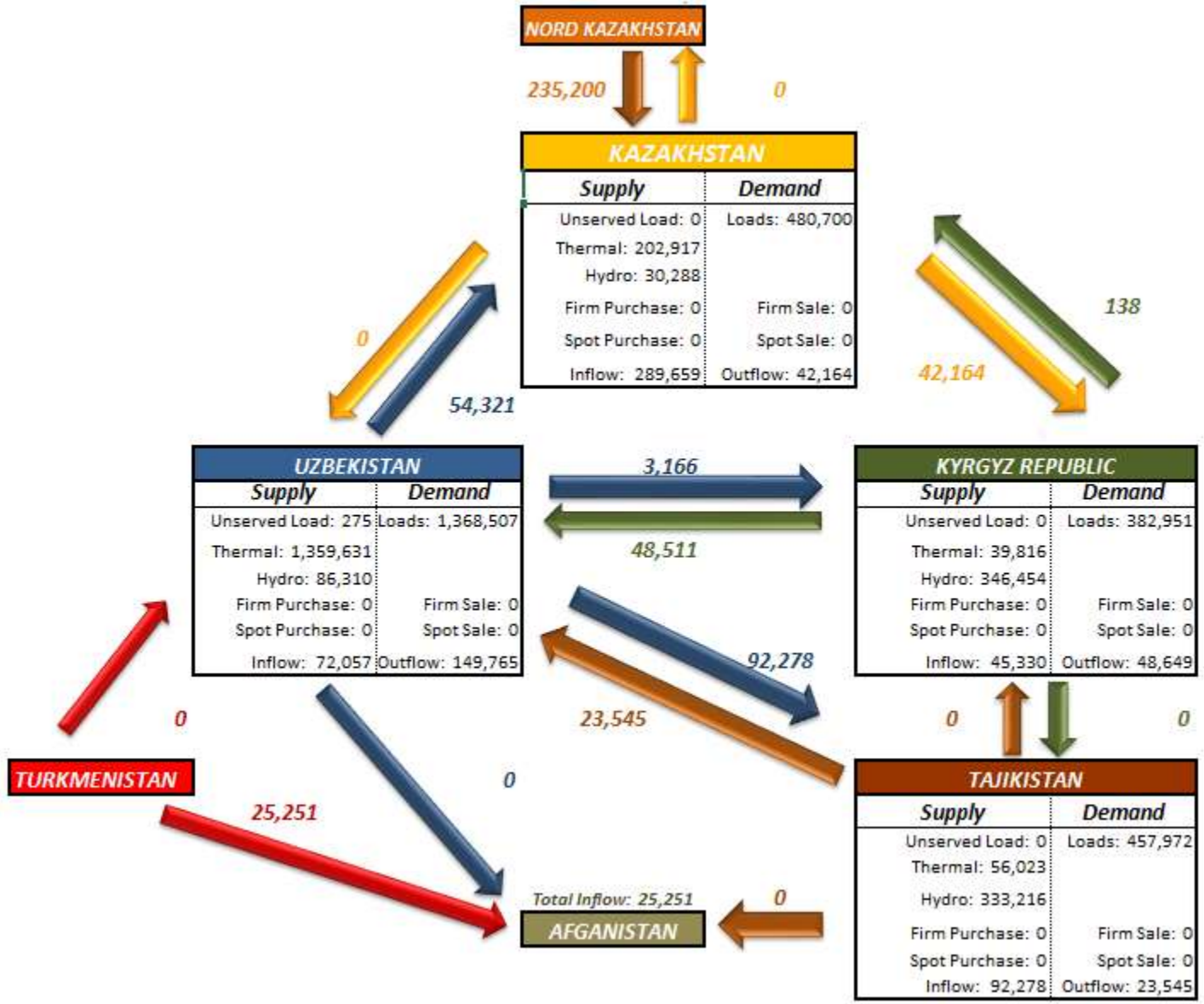
- **Southeast Europe Regional Electricity Market**
  - Argonne applied approach with 16 utilities for USAID project
  - Optimize utilization of hydro and thermal power
  - Identify volume of power transactions
  - Compute financial benefits to buyers and sellers
- **Generation and Transmission Investment Study**
  - PwC applied approach for World Bank and EU
  - Identified timing and location of generation and transmission investments that most benefit market
- **CAREC Power Sector Regional Master Plan**
  - Fichtner GmbH applied approach with utilities from five countries (AFG, KAZ, KGZ, TAJ and UZB) for ADB
  - Promote increasing energy security and energy efficiency, and reducing GHG emissions by optimizing integrated transmission and generation expansion




# GTMax Topology of Central Asian System in 2020



# GTMax Simulated Power Flows for Central Asian System

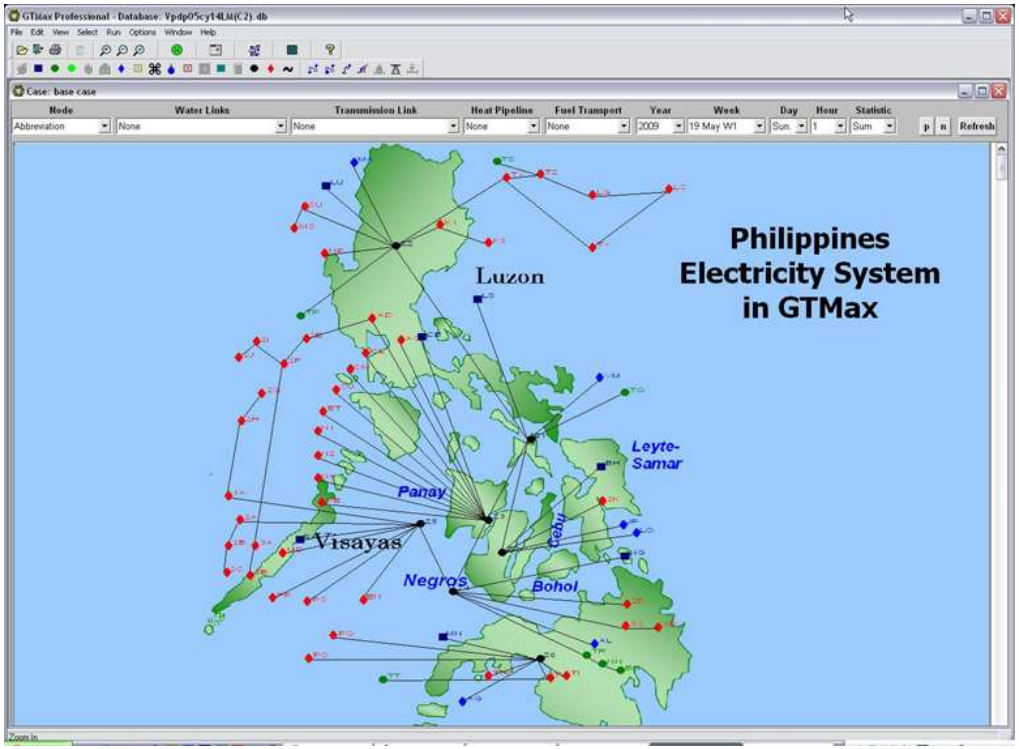


# Topics of Discussion

1. Integrated Electricity System Planning Tools
2. Generation Expansion Planning
3. Regional Energy Exchange and Electricity Markets
4. Transmission Investment Evaluation
5. Hydro-Thermal Asset Optimization

# WASP and GTMax used to Prepare Philippines Power Development Program

- Analysis conducted for the Philippines Department of Energy (DOE)
- Study sponsored by JICA
- Study conducted by Chubu Electric Power Co. with Philippines DOE



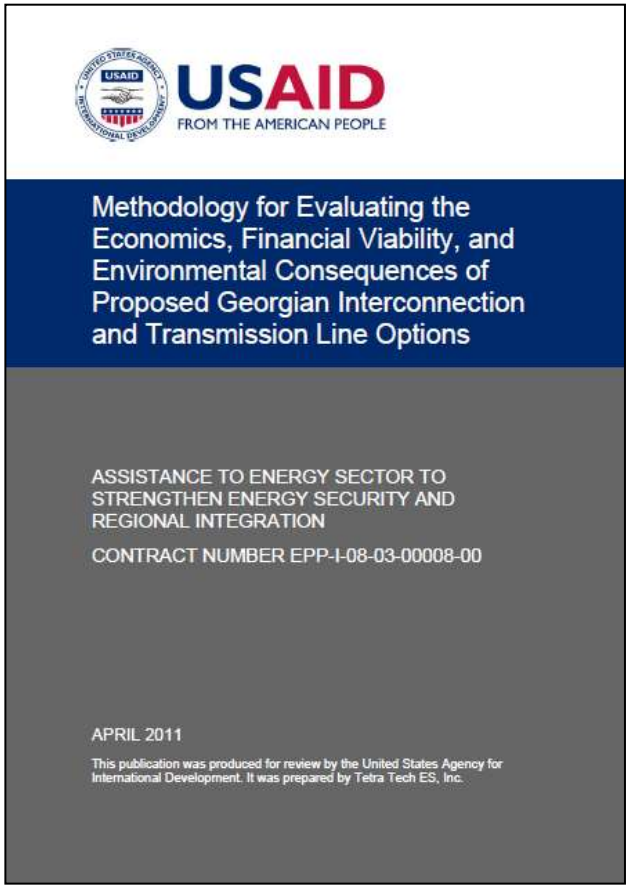

- WASP was used to develop least cost generation expansion plan

- GTMax was used to:
  - Evaluate system operation
  - Determine optimal location of power sources
  - Assess benefits of new transmission lines

# GTMax used as a Framework for Analyzing Future Bilateral Contracts

- Analysis conducted for utility and research institute in each country
- Study sponsored by USAID

- Establishing a “perfect” market is highly unlikely within the foreseeable future
- GTMax was used to:
  - Estimate the economic and financial benefits of coordinated operation
  - Identify opportunities for mutually beneficial short-term firm power sales agreements
  - Compare with economic and financial costs of constructing the new lines



# USAID Armenia/Georgia Study: System Analysis for Republic of Georgia

- **Development GTMax Models for Georgia and Armenia**
  - Initial grid topologies were constructed
    - Detailed network for each national electricity system
    - Simplified topology for joint Armenian & Georgian studies
- **Execute GTMax Model**
  - Model portrays a realistic operational regime in which both countries independently operate its own grid thereby retaining its autonomy and current level of grid control
  - Results used to identify patterns of daily and seasonal power transactions and energy flows across the DC interconnection

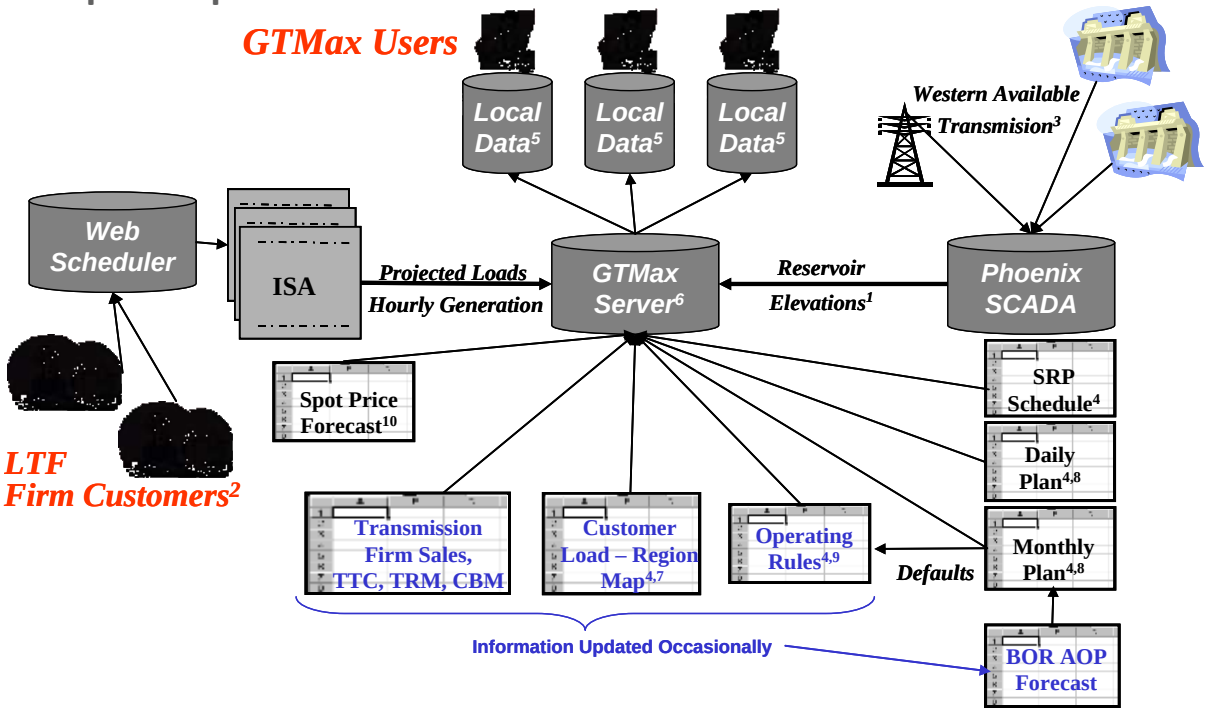
**Computed economic benefits can help set firm contract pricing terms such that both countries share the benefits**

# Topics of Discussion

1. Integrated Electricity System Planning Tools
2. Generation Expansion Planning
3. Regional Energy Exchange and Electricity Markets
4. Transmission Investment Evaluation
5. Hydro-Thermal Asset Optimization

# Examples of GTMax Model Applications in North America

- **Customers include several offices of Western Area Power Administration and U.S. Bureau of Reclamation**
  - Simulate operations of complex cascades of reservoirs and power plants
  - Optimize operations of storage technologies
  - Analyze firm power purchasing programs
  - Determine optimal hourly power plant operations

# In Conclusion:

- **The CAREC Energy Work Plan focuses on:**
  - **Developing the Central Asia-South Asia Energy Corridor**
  - **Resolving regional energy dispatch and trade issues**
  - **Managing energy-water linkages**
  - **Mobilizing funds to build energy assets**
  - **Implementing energy priority projects**
  - **Building capacity and managing knowledge.**

- **The integrated electricity planning tools described in this presentation could provide a common modeling framework for use in analyzing and building consensus on mutually beneficial paths forward**

Thank you for your attention

Comments and questions?