Integrated Resource & Resilience Planning (IRRP) for the Power Sector

USAID Training – March 6, 2017
Session 3: Scaling an IRRP

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Multiple Tools allow for High-Level Review and Detailed Analysis of Issues and Risks

IPM® provides the fundamental analysis necessary for resource planning in coordination with other necessary tools

- Transmission Flows
- LMP and Congestion Forecasting
- Nodal Pricing
- Short-term Dispatch

- Resource Pricing
- Transport Costs
- Network Expansion
- Regional Resource Availability and Constraints

- Entry/Exit Decisions
- Dispatch Decisions
- Compliance Strategies
- Cost Minimization
- Scenario Analysis

- Portfolio Optimization
- Real Options

- Valuation
- Zonal Pricing

Forward Multi-Year (IPM®)

Transmission

Fuel

Network / Stochastic / Monte Carlo
Pecking Order of Key Risks

- **Near-Term to Mid Term**
  - Environmental Regulations
  - Fuel Prices and Fuel Delivery
  - Market Entry/Exit (Capacity)

- **Mid-Term to Long-Term**
  - Environmental Regulations
  - Fuel Prices and Fuel Delivery
  - Transmission
  - Market Entry/Exit (Capacity)
ICF’s Power Market Models

Near-Term Forecast
- Structured Products (up to 5 years)
- Energy Trading
- LMP and Congestion Forecasting
- FTR Trading, Hedging Schemes
- General Nodal Price
- Load-Weighted Zonal Price
- Line/Interface Loadings

Long-Term Forecast
- Asset Valuation (long-term)
- Zonal Prices
- Entry/Exit Decisions
  - New Entry – Generation and Transmission
  - Retrofit
  - Mothballing
  - Retirement
- Allowance Prices
- Environmental Compliance Strategies

e.g. GE MAPS

e.g. IPM
Types of Power System Modeling Tools*

<table>
<thead>
<tr>
<th>Reliability</th>
<th>Distribution Power Flow</th>
<th>Power Flow</th>
<th>Production Costing</th>
<th>Expansion Planning &amp; Policy Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>MARS</td>
<td>CYMDIST</td>
<td>POWERWORLD</td>
<td>DAYZER</td>
<td>AURORA</td>
</tr>
<tr>
<td>REFLEX</td>
<td>EDGE</td>
<td>PSAT</td>
<td>GRIDVIEW</td>
<td>BALMOREL</td>
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<tr>
<td>SERVM</td>
<td>GRIDLABD</td>
<td>PSLF</td>
<td>MAPS</td>
<td>CAPACITY EXPANSION (ABB)</td>
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<tr>
<td>SRAM</td>
<td>OPEN DSS</td>
<td>PSSE</td>
<td>PCLOUDANALYTICS</td>
<td>EGEAS</td>
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<tr>
<td>TRELLS</td>
<td></td>
<td></td>
<td>PROMOD</td>
<td>IPM</td>
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</tbody>
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Most applicable to IRRP

*General categorization – many tools could be placed in multiple categories*
Use of Modeling Tools should be tied to Appropriate Task

<table>
<thead>
<tr>
<th>Issue</th>
<th>First Order Analysis Tool</th>
<th>Second Order Analysis Tool</th>
</tr>
</thead>
<tbody>
<tr>
<td>FTR value or hedging</td>
<td>Nodal Production Cost</td>
<td>- NA -</td>
</tr>
<tr>
<td>Environmental Compliance Decision (switch fuel, install scrubbers, etc...)</td>
<td>IPM (best option; rank decisions)</td>
<td>Production Cost (precise timing)</td>
</tr>
<tr>
<td>Build capacity</td>
<td>IPM (when and where)</td>
<td>Nodal Production Cost (identify node)</td>
</tr>
<tr>
<td>Build Transmission</td>
<td>IPM (when and where)</td>
<td>Nodal Production Cost (narrow location)</td>
</tr>
<tr>
<td>Retire or Mothball</td>
<td>IPM (which facilities and when)</td>
<td></td>
</tr>
<tr>
<td>Invest in a project</td>
<td>IPM (value of investment)</td>
<td>MAPs (near-term dispatch constraints)</td>
</tr>
</tbody>
</table>
Use of Modeling Tools should be tied to Appropriate Task (continued)

<table>
<thead>
<tr>
<th>Issue</th>
<th>First Order Analysis Tool</th>
<th>Second Order Analysis Tool</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost Benefit of RTO</td>
<td>Production Cost</td>
<td>Power Flow, IPM</td>
</tr>
<tr>
<td>Environmental Impact Analysis</td>
<td>IPM</td>
<td></td>
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<tr>
<td>Regulatory Impact Analysis</td>
<td>Varies</td>
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<tr>
<td>LMP Price Projection</td>
<td>Production Cost (near-term)</td>
<td>Production Cost with IPM (long-term)</td>
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<tr>
<td>Alternate Bidding Strategies</td>
<td>Production Cost, IPM</td>
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<tr>
<td>Transmission Loss Modeling</td>
<td>Production Cost</td>
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</table>
Relationship of Power Market Tools

- Near Term Market Analyses – LMP and Congestion Forecasting
- Definition of Market Zones
- Contingency Analysis
  - List of Contingencies and Limiting Elements
  - TTC Analysis (FCTTC and NTTC)
- GE-MAPS™
- Other Input Assumptions
- Simultaneous and Non Simultaneous Energy and Capacity Transfers
- IPM® Market Analysis
- Long-Term Market Analyses and Asset Valuation
Why Consider Alternate IRRP Scopes?

- Planning exercises rely on quality data to develop outcomes.
- Goals and perspectives should be considered in framing an IRRP process.
- An IRP is a living document, reflecting the best knowledge available at the time it is prepared, and the best possible decisions in light of that information.
  - Should IRP results indicate value in renewable development, additional analysis of integration and specific resource potential may be identified.
  - Should IRP results indicate high risk due to limited available fuel diversity, additional fuel supply and procurement analysis may be identified.
IRP Scoping Case Study Background – Puerto Rico

- Lack of oversight and economic downturn resulted in significant financial distress for the Puerto Rico Electric Power Authority (PREPA)
- **Act 57-2014**, known as the Puerto Rico Energy Transformation and RELIEF Act
- Regulation No. 8594 of May 22, 2015, (“IRP Regulation”) established the procedures for the preparation, presentation, evaluation and approval of PREPA’s IRP.
- PREPA filed its first IRP on July 7, 2015. The IRP was found deficient
- Supplemental filings occurred in 2015 and 2016
- In September 2016, the PREC disapproved the IRP and approved a modified IRP which would comply with legal obligations and professional standards.
- On February 10, 2017, PREPA’s motion was denied
- Statutory requirements have a July 1, 2018 filing date for PREPA’s next IRP filing
Putting the Cart Before the Horse

- PREPA failed to utilize a capacity expansion model, as explicitly required in Commission rules
  - PREPA relied on PROMOD, a production costing model
  - PREPA further filed analysis performed using PSSE, a detailed transmission model
  - PREPA performed a quite detailed analysis of its system, but failed to rely on higher level analytical techniques to justify the detailed modeling

- Lack of an optimization structure further meant that PREPA could not evaluate alternate resources on an equal footing

- PREPA further failed to consider alternative risk factors
Discussion Examples
Democratic Republic of the Congo (DRC)

- Second largest country in Africa with a total land area of approximately 2.3 million sq.km., slightly less than one-fourth the size of the U.S.
- Population is estimated to be approximately 81.3 million as of 2016.
- Total hydropower potential is estimated at over 100,000 MW.
- Lowest electrification rates in the world, with approximately only 9% of its total population of 80 million having access to electricity.
- Electrification rate for urban areas is approximately 19%, while the rate in rural areas is 2% (as of 2013).
- Of the total installed power capacity of 2,590 MW, only half is available at any given time.
- High solar energy potential for the country (3.5 – 5.5 kWh/m2/day). No grid-connected solar, only 83 KW of off-grid solar over 836 systems.
- Majority of the country is rural in nature with inaccessible forests and unconnected villages.
- Transmission system is limited and underutilized, provides power mainly to the mines in the southeast.

Source: CIA Fact Book – See link; World Bank – See link
IRRP Considerations - Discussion

- **Demand Analysis**
  - Using 250 kwh/per capita/yr, unmet demand = 4,500 MW

- **Supply Sources**
  - Hydropower
  - Solar
  - Diesel

- **Issues:**
  - Planning hydropower development
    - Large-scale vs. mini- and micro-hydro
  - Type of solar (grid vs off-grid)
  - T&D expansion
  - Off-grid localized networks (microgrids)
  - Privatization (distribution concessions)
  - Public private partnerships (BOO, BOOT etc.)
  - Decentralized control
  - Environmental and social impacts

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**How should the IRRP study and analysis be designed?**