Real-Time Energy Impact Monitors for Residential, Industrial, and Policy Applications

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Team Members

Commonwealth associates, Inc.
DTE Energy
Carnegie Mellon University
Wayne State University
Energy Efficiency MARKETS.com
National Wildlife Federation
ERB Institute
Great Lakes Protection Fund
Shepherd Advisors
EMERGING PRODUCTS

From Prior Project: *Real-Time System Optimization for Sustainable Water Transmission and Distribution*
PEPSO: Polluting Emissions Pump Station Optimization

PEPSO V8.0.3.0

- Multi-objective GA
- Multipoint crossover
- Variable speed pumps
Optimum pump schedule

![Graph showing the best objective function value so far.](image)
Essential Algorithm of Products

**LEEM** - **Locational Emissions Estimation Methodology**

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**Evaluation of a rapid LMP-based approach for calculating marginal unit emissions**

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**HIGHLIGHTS**
- Pollutant emissions estimated based on locational marginal price and eGRID data.
- Stochastic model using IEEE RTS-96 system used to evaluate LMP approach.
- Incorporating membership function enhanced reliability of pollutant estimate.
- Error in pollutant estimate typically <20% for CO₂ and <40% for NOₓ and SO₂.

**GRAPHICAL ABSTRACT**
LEEM Methodology

• Use LMP to predict the marginal fuel type (or...better yet....marginal generator)

• Calculate emissions associated with that fuel type for a specific area
Locational Marginal Prices

- LMPs available from MISO (and other ISOs)
  - (MidContinental Independent System Operator)
- LMPs for select Commercial Pricing Nodes (CPNs) available every 5 minutes
Locational Marginal Prices

- LMPs based on marginal cost of supplying the next increment of electric demand at a specific location

- LMP Accounts for:
  - generation marginal cost (fuel cost)
  - physical aspects of transmission system (constraint in transmission lines)
  - Cost of marginal power losses
Locational Marginal Prices
Locational Marginal Prices

Determine marginal unit type at time \( t_i \)

Marginal Unit at time \( t_i \)

LMP at time \( t_i \)
Fuel Prices

• Get price ranges for Fuel types

   – For Example: DTE Power plants in SE Michigan

<table>
<thead>
<tr>
<th>Marginal Fuel Type</th>
<th>Min LMP</th>
<th>Max LMP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nuclear/Renewable</td>
<td>&lt; $10</td>
<td>$10</td>
</tr>
<tr>
<td>Coal</td>
<td>$10</td>
<td>$50</td>
</tr>
<tr>
<td>Nat. Gas &amp; RFO</td>
<td>$50</td>
<td>$180</td>
</tr>
<tr>
<td>Dist. Fuel Oil</td>
<td>$180</td>
<td>&gt; $180</td>
</tr>
</tbody>
</table>

• LMP $\rightarrow$ Marginal Generator Type $\rightarrow$ Air Emissions
Emission Rates

• LMP → Marginal Generator Type → Air Emissions

• Measured Air Emissions Data from EPA’s eGRID
  – (Emissions & Generation Resource Integrated Database)
  – Data on thousands of power plants in the US

• Sort by EGCL code (Electric Generating Company, Location-Based)
  – i.e., all of DTE-operated plants in SE Michigan
Emission Rates

- Calculate average emission rate for entire area for each fuel type
- Example, Detroit Edison: (2008 data)

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Nuclear</th>
<th>Coal</th>
<th>Natural Gas</th>
<th>Distilled Fuel Oil</th>
</tr>
</thead>
<tbody>
<tr>
<td>SO2</td>
<td>0</td>
<td>10.54</td>
<td>1.65</td>
<td>2.3445</td>
</tr>
<tr>
<td>NOX</td>
<td>0</td>
<td>3.05</td>
<td>1.57</td>
<td>21.73</td>
</tr>
<tr>
<td>CO2 equiv</td>
<td>0</td>
<td>2071</td>
<td>2292</td>
<td>1862</td>
</tr>
<tr>
<td>Hg</td>
<td>0</td>
<td>5.26E-05</td>
<td>3.62E-06</td>
<td>5.81E-06</td>
</tr>
<tr>
<td>Pb</td>
<td>1.09E-07</td>
<td>3.10E-05</td>
<td>1.66E-06</td>
<td>3.65E-05</td>
</tr>
</tbody>
</table>

- LMP ➔ Marginal Generator Type ➔ Air Emissions
1. An individual initiates the use of an energy consuming device (running a dishwasher, recharge an electric car, etc.)
2. LEEM identifies pollutant emissions scenarios
3. The consumer is presented with two options, both of which present the finish time and the anticipated pollutant emissions:
   1. UnECO
   2. ECO (within given time constraints)

Assuming ECO option is selected:
1. LEEM modifies power demand to minimize pollutant emissions
2. Marginal units reduce generation
3. Pollutant emission at marginal unit are reduced
4. Once cycle is complete, pollutant emissions savings reported to consumer
Validation of LEEM

- 99 generators, 120 branches, and a total of 8550 MW load and 10215 MW generation capacities
Validation of LEEM – Cont’d

(a) 5% price std. var.

(b) 30% price std. var.
LEEM Validation on Eastern Interconnection

Over 60,000 buses

Tool: PowerWorld
Going to Market

• LEEM needs broad distribution & utilization to make a difference – but where and how?
  – Appliances (help from Energy Star?)
  – Heating/Cooling equipment
  – Energy Display devices
  – Buildings (help from LEED?)
  – Pollution aggregators and brokers
  – Demand Side Management
  – Others? Who?
Going to Market

• More value adding features?
  – Include particulates
  – Aggregate emissions into a single number
  – Display estimated savings from time shifting
  – Enable CO2 counting and aggregation

• What more do you need to see or know to be sold on LEEM’s value and credibility?

• What other customer or market considerations will influence success?
Further Information

Contact Dr. Carol Miller: 313-577-3842; ab1421@wayne.edu

YouTube links:
• LEEM: http://www.youtube.com/watch?v=6DaE1xGbphs
• HERO: http://www.youtube.com/watch?v=BfLTY8sFiQ8

Also embedded YouTube videos on our website at:
• LEEM: http://engineering.wayne.edu/wsuwater/emissions-model/about.php
• HERO: http://engineering.wayne.edu/wsuwater/about/hero.php