SMART POWER GENERATION

Utility Portfolio Optimization with Smart Power Generation

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Market Development Analyst
Wartsila Power Plants

Flexible Power Symposium
Vail, CO Feb 6, 2014
Fast, Dynamic and Efficient Generation

Improves system efficiency, enables renewables, lowers cost.
Agenda

System Scale Optimization (Dispatch Modeling)

Project Scale Optimization (LCOE analysis)

Utility Scale Optimization (Capacity Expansion Planning)

An Example

Summary
Technologies that are
- More Efficient
- More Flexible
- Competitive (EPC, VOM, FOM) and
- Reliable

*e.g.*, *Smart Power Generation*

Reduce operational costs at the SYSTEM SCALE.

<table>
<thead>
<tr>
<th>System</th>
<th>New Build Capacity (%) of Fleet by 2020+</th>
<th>System OPEX Savings (%) if Wärtsilä new builds instead of GT/GTCC</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spain</td>
<td>8</td>
<td>6</td>
<td>Wärtsilä</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>5</td>
<td>3 - 5</td>
<td>RedPoint</td>
</tr>
<tr>
<td>CAISO</td>
<td>~7</td>
<td>4 - 12</td>
<td>DNV Kema, Energy Exemplar</td>
</tr>
</tbody>
</table>
Hows does SPG reduce system costs?

- Individual Units cycle w/o added cost
- Part Load Efficiency ~ Full Load
- Take over AS provision (LF, Reg Up) and ramping
- Reduce Cycling (cost!) on other system components

With @ 5 GW GT/GTCC Buildout in 2020

Wärtsilä as Smart Power Generation

With @ 5 GW Wärtsilä Buildout instead

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Agenda

- System Scale Optimization (Dispatch Modeling)
- Project Scale Optimization (LCOE analysis)
- Utility Scale Optimization (Capacity Expansion Planning)
- An Example
- Summary
Levelized Cost of Energy (LCOE) Takes into account

- Capex ($/kW)
- Efficiency & Fuel Prices
- VOM & FOM
- Time (20 or more years)
- Financials (Escalation, Discount Rate, WACC)
- LCOE Results in Net Present Value, NPV ($/MWh)
Technologies considered (100 - 400 MW)

- **CAPEX ($/kW)**; 50SG ~ LMS100 (@ $800/kW EPC based on recent projects- STEC II and Portland General Electric), 34SG & Flexicycle™ are @$50 and $150/kW higher respectively (indicative, rule of thumb).

- **Construction time (months)**; 12 mo/all, except Flexicycle™ @ 18 mo.

- **Capacity (MW), Heat Rate**; (GTPRO V23)

- **Avg. Degradation of heat rate & capacity over time**; 2% each for GT, 0.5% and 0% respectively for Wärtsilä

- **Fuel Price**; CA Energy Commission 20 year forecast

- **VOM & FOM**; Equivalent across all

- **Financial**; 7% discount rate & WACC, 2% Escalation, 20 year evaluation
200 starts/year assumed.

Wärtsilä ~ optimal LCOE based on Capex + Heat Rate
In these analyses we do not account for the cost of water. Wärtsilä does not use water!

- Wärtsilä simple cycle uses radiators
- Wärtsilä Flexicycle™ uses Air Cooled Condensers

In comparison
- LMS100 uses water injection
- (2,600 gallon/hour/unit)
- Max performance assumes cooling tower!
- Other Aero GTs get max performance with water injection as well.
- GTCCs can use ACCs but at higher CAPEX & Reduced performance
Agenda

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An Example

Summary
Utility Scale Optimization (Capacity Exp Planning)

SPG Optimizes OPEX at System Scale

SPG Competitive LCOE at Project Scale

Utility has a different criteria; Minimize NPV of CAPEX + OPEX over 10-20 year horizon
Integrated Resource Planning (simplified)

Existing Portfolio

Supply Options
- Imports
- Demand Response

New Capacity?
- GT, GTCC
- Wärtsilä

Requirements
- AS
- Reserve Margin

Capacity Expansion Model

Fuel Price Forecast

Load Forecast

Wind/Solar Forecasts

Weather/Hydro Forecasts

Least Cost Portfolio (Next 10-20+ years)
Consultant & Method

Energy Exemplar, Sacramento CA
- Set up model(s)
- performed simulations
- collected/summarized results

PLEXOS™ LTPLAN module
- LDC methodology (used for this analysis)
- 1 hour time blocks
- No account for net load dynamics
- Supplies Capacity to meet load

PLEXOS™ Chronological Mode under Investigation (Join our Webinar Feb 26!)
- Explicitly accounts for net load ramping
- Supplies Capacity & Flexibility
One more word on the method

LDC ~Traditional Method Utilities use. Prepares you for the dream trip

Chronological Method prepares you for the real voyage
The Utility - Existing Capacity & Supply

**Installed Capacity:** 26.64 GW

- **Boiler (ST):** 25%
- **Wind:** 17%
- **Solar:** 26%
- **GTCC:** 14%
- **Other:** 6%
- **GT:** 2%
- **Hydro:** 8%
- **Nuclear:** 2%

**Supply(1):** 9 GW Transmission

**Supply(2):** 1.8 GW Demand Response

*Portfolio representative of a Western Utility with*

- Significant buildout of Renewables (~30% of Energy)
- Reliance on gas-fired thermal
Forecasts / Data Sources

Mid Gas Pricing projection

Mid Load Growth*

*See: http://www.energy.ca.gov/2012_energypolicy/documents/2012-02-23_workshop/mid_case/
Forecasts (Data Sources)

- Renewable profiles (aggregated by type; solar and wind)

- Hydro profiles

## Other / Miscellany

<table>
<thead>
<tr>
<th>Input</th>
<th>Source/Methodology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planning Horizon</td>
<td>10 years</td>
</tr>
<tr>
<td>Capacity Reserve Margin</td>
<td>15%</td>
</tr>
<tr>
<td>Retirements</td>
<td>@ 6GW of thermal retirements, year 7-10</td>
</tr>
<tr>
<td>Firm Capacity</td>
<td>Thermal 100%, Interchange ~ 100%, Hydro 82%, Wind/Solar (variable)</td>
</tr>
<tr>
<td>GT Combined Cycle</td>
<td>Set ~ 55% of capacity additions (max) to match known IOU buildout</td>
</tr>
</tbody>
</table>
# New Capacity Options / Scenarios

**Data defined for each Plant:**
- Full/part load heat rate (GTPRO V23)
- Forced outage rates, MTTR
- Start time / Start Cost
- VOM & FOM
- Min up/down times
- Min Stable Load

## BASE Scenario

<table>
<thead>
<tr>
<th>Plant</th>
<th>kW</th>
<th>Cost per kW</th>
</tr>
</thead>
<tbody>
<tr>
<td>LMS100, 106 MW</td>
<td>$1100/kW</td>
<td></td>
</tr>
<tr>
<td>LM6000, 50 MW</td>
<td>$1200/kW</td>
<td></td>
</tr>
<tr>
<td>GTCC 1x1, 300 MW</td>
<td>$1250/kW</td>
<td></td>
</tr>
<tr>
<td>GTCC 2x1, 600 MW</td>
<td>$1150/kW</td>
<td></td>
</tr>
<tr>
<td>GTCC 1x1, 330 MW</td>
<td>$1350/kW</td>
<td></td>
</tr>
</tbody>
</table>

## FLEX Scenario, same as Base Plus...

<table>
<thead>
<tr>
<th>Plant</th>
<th>kW</th>
<th>Cost per kW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wärtsilä 20V34SG (50 MW+)</td>
<td>$1150/kW</td>
<td></td>
</tr>
<tr>
<td>Wärtsilä 18V50SG (90 MW+)</td>
<td>$1100/kW</td>
<td></td>
</tr>
<tr>
<td>Wärtsilä Flexicycle (100 MW+)</td>
<td>$1250/kW</td>
<td></td>
</tr>
</tbody>
</table>

### Results

#### Less Wärtsilä capacity needed

<table>
<thead>
<tr>
<th>New Capacity (GW)</th>
<th>BASE</th>
<th>FLEX</th>
</tr>
</thead>
<tbody>
<tr>
<td>GTCC</td>
<td>3,358</td>
<td>3,358</td>
</tr>
<tr>
<td>GT (LM6000)</td>
<td>49</td>
<td>-</td>
</tr>
<tr>
<td>GT (LMS100)</td>
<td>2,832</td>
<td>-</td>
</tr>
<tr>
<td>Wärtsilä 34SG</td>
<td>-</td>
<td>64</td>
</tr>
<tr>
<td>Wärtsilä 50SG</td>
<td>-</td>
<td>2,686</td>
</tr>
<tr>
<td>TOTAL GW</td>
<td>6,240</td>
<td>6,109</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>NPV($000)</th>
<th>BASE</th>
<th>FLEX</th>
</tr>
</thead>
<tbody>
<tr>
<td>OPEX</td>
<td>57,028,791</td>
<td>56,891,253</td>
</tr>
<tr>
<td>CAPEX</td>
<td>4,637,962</td>
<td>4,550,827</td>
</tr>
<tr>
<td>TOTAL</td>
<td>61,666,753</td>
<td>61,442,079</td>
</tr>
</tbody>
</table>

#### Savings are Conservative!
- No Net load fluctuations
- No Start Costs / Cycling
- No Part Load Operation

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Portland General Electric (Oregon, Pacific Northwest)

- 4,000 sq. mi territory
- Population ~ 1.7 million

- IRP process, independent evaluator chosen by Oregon PUC
- Renewable Integration, 200 MW flexible capacity need
- Virtual tie: Wärtsilä 50SG vs. LMS100 ($/kW ~ equivalent)
Portland General Electric (Port Westward II Project)

The Tie Breaker: *Portfolio Dispatch Analysis*

- Flexibility of Wärtsilä provided greatest FLEET level operational savings

- 12 x Wärtsilä 18V50SG chosen
Validation of Effect

BASE (No SPG)

With Wärtsilä

Wärtsilä Optimization of Utility Fleet (PGE)

With @ 5 GW GT/GTCC Buildout in 2020

Wärtsilä Optimization of CAISO fleet (DNV Kema)

With @ 5 GW Wärtsilä Buildout instead
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Summary

- Smart Power Generation optimizes portfolio (ISO to IOU scale) CAPEX & OPEX while integrating renewables and providing reliable power.

- Smart Power Generation does this by providing efficient flexibility and capacity at competitive capital costs, allowing other assets in the fleet to reach their optimal performance
  - Reduces fuel consumption
  - Reduces CO2
  - Ultimately reduces costs borne by rate payers

- Wärtsilä is the LEADER in Smart Power Generation
Thank You

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➢ Please Attend our Webinar, Wednesday Feb 26, 2014 12:00 to 1:00 EST, https://www1.gotomeeting.com/register/165409161