The World Cannot Wait: Innovations for the Energy Transition

Debora Frodl
Founder, DF Strategies LLC
April 19, 2018
Energy transition continues amidst uncertainty
Drivers of the energy transition

- Decarbonization
- Decentralization
- Digitization
- Mobility Disruption
Decarbonization – competitive clean energy

Average US renewable energy PPA prices

- **Utility-scale PV**
  - 2008-16 Utility-Scale PV down 83%

- **Wind**
  - 2008-16 Wind down 71%

- **Gas**

Decade 2006-2016:
- Utility-scale PV: 250, Wind: 200, Gas: 150, Other: 100

**December 2017 Solicitation:**
- 400 Bids
- $21/MWh median wind+storage bid
- $36/MWh median solar+storage bid

Source: Xcel Energy

Note: Levelized, time-of-day adjusted contract price shown in real 2015 USD. 2016 PV PPA price based on preliminary data and subject to review. Source: U.S. Department of Energy (LBNL), Bloomberg New Energy Finance.
Decentralization – distributed energy accelerating

U.S. Solar PV Deployment Forecast

2007-17 59% AAGR
53GW installed

Source: SEIA 2018
Digitization – maximizing operational efficiency

<table>
<thead>
<tr>
<th>Industry</th>
<th>Cost Savings ($B)</th>
<th>Carbon Reduction (Mt/y)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power</td>
<td>$14</td>
<td>495</td>
</tr>
<tr>
<td>Lighting</td>
<td>$30</td>
<td>132</td>
</tr>
<tr>
<td>Aviation</td>
<td>$14</td>
<td>45</td>
</tr>
<tr>
<td>Railway</td>
<td>$3</td>
<td>19</td>
</tr>
<tr>
<td>Ground Transportation</td>
<td>$20</td>
<td>132</td>
</tr>
</tbody>
</table>

Close the global carbon gap by almost 30%.

CO₂ emissions could be reduced by 823Mt annually.

Industry could save $81B per year in fuel cost.

Disruption – big in mobility

**Connected**

- Ride sharing
- Fleet & logistics
- Autonomy
- Electrification
Energy transition needs innovation from everywhere

Corporations
- Walmart
- Microsoft
- Google
- Amazon
- AES
- Schneider Electric
- BYD
- Apple

Startups
- sonnen
- Geli
- ELEMENT ANALYTICS
- XLhybrids
- FireFuel

Government
- National Renewable Energy Laboratory (NREL)
- Argonne National Laboratory
- Sandia National Laboratories
- Lawrence Livermore National Laboratory
- ARPA-E

Build Your Dreams
Corporate innovation: Ecomagination case study

### Investment

<table>
<thead>
<tr>
<th></th>
<th>Ecomagination R&amp;D investment commitment:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$22.5B</td>
</tr>
<tr>
<td>Investment to date</td>
<td>Goal</td>
</tr>
</tbody>
</table>

Ecomagination solution revenue to date: $300B

### Environmental Impact

<table>
<thead>
<tr>
<th></th>
<th>GHG emissions and reduction progress:</th>
</tr>
</thead>
<tbody>
<tr>
<td>GHG</td>
<td>Start</td>
</tr>
<tr>
<td></td>
<td>2011</td>
</tr>
<tr>
<td>GHG</td>
<td>-18%</td>
</tr>
</tbody>
</table>

### Solutions

80 Ecomagination qualified Solutions:

<table>
<thead>
<tr>
<th></th>
<th>Water</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Start</td>
</tr>
<tr>
<td></td>
<td>2011</td>
</tr>
<tr>
<td>Water</td>
<td>-20%</td>
</tr>
</tbody>
</table>

(goal surpassed)

Delivering economic and environmental outcomes for customers and the world
Ecomagination solutions drive customer outcomes

5.5 gigatons CO₂
1.3 billion gallons water
$3.5 billion

THE IMPACT
Ecomagination innovation spans industry

**Digital Wind Farm**
Combines GE’s modular 2MW turbine platform with robust digital infrastructure to increase production by 20%.

**Solar Inverter**
New 1.5kV solar inverters, using silicon carbide to reduce the size of a 1MW inverter by 40% and boost power conversion efficiency of 99%.

**9H Gas Turbine**
3000+ sensors collecting data. Flexibility for changing power demand – 62% efficiency.

**Brilliant Manufacturing**
Combines GE’s lighting & Predix platform with Intel’s chips & computing power to improve manufacturing productivity.

**Supercritical CO₂ Turbine**
New smaller-sized turbine that uses supercritical CO2 to provide comparable power output with the potential for 50% efficiency.
Digital solutions accelerate efficiency & decarbonization
Combining industrial hardware with internet-enabled software

PREDIX
masters data with speed and scale

Open Ecosystem  Edge-to-Cloud Security  Predictive  Mobile  Big Data Analysis  Industrial Scale  Faster Innovation
Commercial Partnerships – co-develop new technology solutions, new business models, test and scale existing solutions

Collaborative Innovation – partner on open innovation challenges or hackathons to solve tough challenges

Ecomagination Treasure Hunts – collaborate to identify opportunities to deploy solutions to reduce energy and water waste

Energy Ventures – provide capital, technical and commercial expertise to support scaling startup companies
Customer case study

Bringing Ecomagination plus an innovative network to realize LStar’s vision for a smart, sustainable, innovative and inclusive city
Key Highlights

✓ Align strategy to transformation drivers – 4D’s
✓ Innovation comes from everywhere
✓ Corporative innovation critical, drives scale and impact
✓ Platforms accelerate digital transformation
✓ Networks create collaboration opportunities
✓ Massive opportunity remains… *world cannot wait*
Thank you!