OBJECTIVES

- Who and What is TDX Power
- Future Paradigm Shifts
- Why Renewables
- How Much Renewable Power Can A Utility Utilize?
- What are Renewable Power Characteristics?
- Traditional Utility Control Approach for Renewables
- Power – Electricity – Energy, Different or The Same?
- TDX’s Alternative Renewable Control Approach
- Achievements by TDX – St Paul POSS Camp
- TDX Vision – 80% Renewable by 2020
- Challenges Ahead
TDX Power – Vision & Mission

- **Vision:**
  
  We are the future of cost-effective, integrated, high-renewable penetration energy solutions.

- **Mission:**

  Provide stakeholder's with sustainable and exportable job opportunities that become the catalysis for community economic sustainability, education, and other shareholder benefits.

  Our mission is to lead the world in cost-effective, sustainable, high-renewable penetration utility energy systems first by demonstrating success within Alaska and then the world.
TDX Power – Utility Locations
ENERGY OR POWER?

What do you see?
By shifting perspective you might see an old woman
or a young woman

The Speed of Change?

Major Communication Paradigm Shifts

x axis = Year CE
y axis = Number of years to reach 50 million users

Gutenberg’s Press 1450
Newspapers 1645
Telegraph 1835
Movies 1878
Telephone 1915
Radio 1920
Television 1930
Internet (ARPA) 1969
Mobile Phones 1982
http 1996

Stark Reality Check
STAY WITH TRADITIONAL OR CHANGE?
Landline Phones Are Getting Closer to Extinction

Victor Luckerson  @VLuck  |  July 8, 2014

41% of American homes are now wireless-only

It’s not just Millennials anymore—a growing number of older American adults are getting rid of their landlines and going cellphone-only. 41 percent of U.S. households were wireless-only by the end of 2013, according to new data from the National Center for Health Statistics.

Young adults are
CHANGE MANAGEMENT?

Who will bring our electrical grid out of the Dark Ages?

You and I will. Creating a sustainable, smarter electrical grid for the future.

WHY USE RENEWABLES?

- Reduce and stabilize electric costs
- Reduce fossil fuel consumption
- Reduce GHG emissions
- Government or State mandates
- Feel Good and Green

Sustainability
- minimize economic cost associated with importing fuel
- create local jobs & keep $$ within the local economy
- utilize local natural resources
- Remote community livelihood and survivability
- Political and economic independence from external sources
WHEN IS THERE TOO MUCH RENEWABLE POWER?

Traditional Utility Reasons for Curtailment:

- Electricity generation and demand must be kept in balance at all times to maintain reliability and power quality.
- If electricity generated exceeds demand, the electric system can overload and become unstable.

Is this really the True?

What do you believe?
How Much Renewable Power Can A Utility Utilize?

What are Renewable Power Characteristics?

UK Wind Output – December 2011
Solar Power Output Variability

Data View
Solar Resource
From Oct 23, 2013 To Oct 30, 2013

Data View
Solar Resource
From Oct 26, 2013 To Oct 27, 2013

Kord Christianson, TDX Power – UAF Lunch & Learn · Alaska Renewable Energy Self-Sufficiency
## TDX Renewable Controls Approach

### Classification of Wind-Diesel Hybrid Systems by Wind Penetration

<table>
<thead>
<tr>
<th>Penetration Class</th>
<th>Operating Characteristics</th>
<th>Penetration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>• Diesel runs full time</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Wind power reduces net load on diesel</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• All wind energy goes to primary load</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• No supervisory control system</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt; 50%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt; 20%</td>
</tr>
<tr>
<td>Medium</td>
<td>• Diesel runs full time</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• At high wind power levels, secondary loads dispatched to ensure sufficient diesel loading</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Alternatively, wind turbines are curtailed during high winds and low loads</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Requires relatively simple control system</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>50 – 100%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>20 – 50%</td>
</tr>
<tr>
<td>High</td>
<td>• Diesels may be shut down during high wind availability</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Auxiliary components required to regulate voltage and frequency</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Requires sophisticated control system</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>100 - 400%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>50 – 150%</td>
</tr>
</tbody>
</table>
ACHIEVEMENTS BY TDX – ST PAUL POSS CAMP
Balancing Generation & Loads

- Broadly dispatching fast-acting dispatchable load technologies will allow integrated renewable systems to increase wind power resources - by providing effective regulation of the power grid.

- Renewable energy resources are naturally variable in their generation. Wind ramps up and down quickly – and isn’t often, if ever, in sync with the ups and downs of the demands on the grid.

- Fast acting dispatchable loads alleviate variability while addressing the need for grid management and the ability to regulate available power.

- Providing a consistent energy supply within a grid that inherently varies its demand highlights the stability challenge faced by the operator.
St. Paul POSS Camp

- **Diesel Power Plant:** (2) 150 kW diesel gensets
- **Primary load:**
  - ~70 kW average
  - ~160 kW peak (with load growth planned)
- **Wind Turbine Capacity:** (1) 225 kW wind turbine
- **Additional Components:**
  - 300 kVA Synchronous Condensor
  - 466 kW electric hot water tank (Secondary Load)
- **System Control**
- **Average annual penetration:** ~100%
- **Peak penetration:** >400%
Simple Electrical One-Line
St. Paul Wind-Diesel System Architecture

- wind turbine
- diesel gensets
- synchronous condenser
- hot water tank
- remote monitoring
- system controller
- electrical loads
- thermal loads

TDX Power
ST PAUL - POSS ELECTRICAL ONE-LINE
INTEGRATED ENERGY PROVIDER CONCEPT

GRID-INTERACTIVE ELECTRIC THERMAL STORAGE

REDIRECT EXCESS WIND ENERGY

ENERGY STORED IN HEATERS AS NEEDED BY GRID FLUCTUATIONS

GIVEN A SIGNAL FROM THE UTILITY, THE HEATERS ADD OR SHED LOAD

WIND POWERED HEATING SYSTEM

UNDER NORMAL OPERATION THE HEATER IS POWERED BY GRID ENERGY SOURCED FROM WIND, AND IF THE WIND ISN’T BLOWING THE SYSTEM UTILIZES PREVIOUSLY STORED THERMAL ENERGY

Medium Response – Dispatchable Loads

Using Electric Thermal Storage for Frequency Control

- If ETS load is increased by this amount, frequency will fall to 60 Hz.
- Two-way grid communication controls frequency
- Area Control Error (ACE) is the difference between supply and demand of electricity
- ETS heaters respond to an automatic generation control signal to regulate power

Sample 30 minute interval of area control error

ST PAUL HIGH WIND PENETRATION RESULTS

<table>
<thead>
<tr>
<th>St. Paul - Wind Energy - Annual Power Production Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross Total kWh Generated</td>
</tr>
<tr>
<td>kWh Generated Diesel</td>
</tr>
<tr>
<td>kWh Generated Wind</td>
</tr>
<tr>
<td>System Efficiency W/D kWh/gal</td>
</tr>
<tr>
<td>kWh Thermal Tank Usage</td>
</tr>
<tr>
<td>kWh Facility Usage</td>
</tr>
<tr>
<td>% Parasitic Losses</td>
</tr>
<tr>
<td>Diesels Off hours</td>
</tr>
<tr>
<td>Diesels Off (% of year)</td>
</tr>
</tbody>
</table>
TDX Vision 80% Renewable by 2020

- 80% Renewable (Electricity, Heat & Ground Transportation) by 2020 for the community of St Paul
  - More wind turbines, hydro, hydrokinetic & solar
  - Dispatchable renewable heat in every home/building
  - Microgrid controls, measurement, verification
  - Community Energy Baselines
  - RCA Regulation issues
  - Utility integration issues
  - Electric Vehicles & Charging Stations

- 70% Renewable by 2022 for Sand Point
- 70% Renewable by 2023 for Adak
80% by 2020 Timeline

- **2015**: Define Vision/specifications, Qualify Opportunities, Identify Hurdles
- **2016**: Define Baseline, Fuel Consumption, Modeling Impact, Study Wind Farm
- **2017**: Create Road Map, Financial Requirements, Define Gating Events
- **2018**: Expanding Wind Farm, Thermal Use Evaluation, Electrical Efficiency Measures
- **2019**: Expanding Wind Farm Evaluation of Solar

**GOAL**
ST. PAUL
80% RENEWABLE ENERGY (ELECTRICITY HEATING & TRANSPORTATION) BY 2020
Barriers to High Renewable Development?

Paradigm Shift:

- High Renewable Penetration can and is being done
- Normal Power vs intermittent dispatchable renewable power/energy
- Fast dispatchable loads are essential for control
- Be creative identifying fast dispatchable loads
- Curtailment should become a legacy of the past
- Utilize stranded resources
- Who owns, operates, and maintains dispatchable loads
Barriers to High Renewable Development?

- Financial:
  - Washington is dysfunctional – Juneau is broke
  - Creative capital stack financing is required, not grants
  - Solid project financing packaging, backed with data
  - Community Energy Baseline, not fragmented audits
  - Measurement and Verification of results
  - Positive State/Federal incentives, backed by certainty
  - Investor Capital recovery = Fuel for COPA and PCE?
BARRIERS TO HIGH RENEWABLE DEVELOPMENT?

- Technical:
  - Multi-level distributive control of dispatchable loads in renewable only mode
  - Utility Regulation control/ownership
  - Wheeling rates
  - Utilities as aggregator or facilitator

- Human:
  - Training and cross functional job skills
  - TDX Renewable Technology Center
  - Paradigm shift thinking
Barriers to High Renewable Development?

- Regulatory/Legislative:
  - Power Cost Equalization (PCE) & Cost Of Power Adjustments (COPA)
  - Regulatory Commission of Alaska – Legislative issues
    - Thermal sales – RCA regulation
    - Electric utility – RCA regulation
    - Preferred (higher) capital cost recovery for renewables
  - State/Federal tax credits, incentives, uncertainty
Challenges Ahead

VARIABLE RENEWABLE SUPPLY

MANAGE WITH GRID-INTERACTIVE ELECTRIC THERMAL STORAGE

VARIABLE DEMAND

MANDATORY GRID STABILITY

Questions?

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