Hybrid Power Systems & Storage

Buena Vista, CO
Hybrids: Big Picture

- What Are They?
  Generation from Multiple Sources
- Are They New?
  Certainly Not
  Always Have Been Hybrid Power Systems
  Large Networks are Hybrids

Paul Gipe, wind-works.org
Classification: Size

- **Capacity**
  kW, MW

- **Population**
  Dozens, Hundreds, Thousands, Tens of Thousands

- **Nation States**
  After All, What is a Network but a Hybrid

Paul Gipe, wind-works.org
Classification: Remoteness

• Connected to the Grid
  Islands Connected to Mainland
  Backup Power
  Frequency Stabilization
  Villages & Regions

• Not Connected to Grid
  Islands Not Connected to Mainland
  Remote Villages
  Homesteads Off-the-Grid

Paul Gipe, wind-works.org
Hybrids--Resources

- Most Commonly
  Hydro, Wind & Solar
- Often
  Biogas
- Occasionally
  Geothermal
Hybrids--A State of Mind

• Texas?
  Only Limited Connection to USA
• Iceland--The Island Nation
Some Examples

• Iceland
  300,000 people; 100,000 km²

• Samsø (Island), Denmark
  4,3000 people; 112 km²
  Interconnected with Mainland

• El Hierro (Island), Spain
  10,000 people

• Pellworm (Island), Germany
  1,200 people; 37 km²

• Dardeshiem, Germany
  1,000 people

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Iceland

• Electricity: 100% Renewable
  75% Hydro, 25% Geothermal
  2 Token Wind Turbines

• Heating: 85% Renewable
  Geothermal Hot Water
Samsø: Denmark’s Renewable Energy Island

- **100% Electricity**
  Onshore Wind Turbines (Cooperatively-Owned) Connected to Mainland

- **70% Heat**
  Biomass: Straw Burning District Heating

- **Transportation**
  Offsets
    Offshore Wind Turbines
  Substitution
    Biodiesel

Paul Gipe, wind-works.org
El Hierro (Canary Islands), Spain

- Wind: 11 MW, 5 Wind Turbines
- Pumped Storage
  Energy & Frequency Control

Paul Gipe, wind-works.org
El Hierro, Canary Islands

- 100% a Favorite of Rightwing Ire
- 100% of What?
- Confusion Between Electricity & Energy
- ~40% of Electricity
- Target Now 80% Of Electricity

Paul Gipe, wind-works.org
Pellworm (Island), Germany

• Interconnected with Mainland
• 200% RE supply
  70% Wind
  10% Solar PV
  6% Biogas

Paul Gipe, wind-works.org
Pellworm (Island), Germany

- Demonstration Hybrid
- Wind, Solar, Biogas
- 700,000 kWh/yr

Paul Gipe, wind-works.org

http://reregions.blogspot.com/2010/03/pellworm-island.html
Dardesheim, Germany’s Renewable Energy Village

Wind, Solar PV, Biogas
EV Charging
Dardesheim Wind

- 62 MW Wind
  - 28 Enercon E70s, 1 Enercon E126 (6 MW)

Paul Gipe, wind-works.org
Dardesheim Solar & Biogas

- Solar Pig Sty
- Biogas from Manure

Paul Gipe, wind-works.org
Dardesheim, Germany

- 10X Total Energy Needs
- 40X Electricity Consumption
- Wind: 120-130 million kWh/yr
- Solar PV: 250,000 kWh/yr
- Biogas

Paul Gipe, wind-works.org
Esperance, Australia

- 1,000 people, Very Remote
- 1993: 2 MW Wind Ten Mile Lagoon
- 2003: 3.6 MW Wind Nine Mile Beach
- 23% Wind
- Gas Turbines

Paul Gipe, wind-works.org

By Tam - flickr: Ten Mile Lagoon Wind Farm Esperance
Saint Paul, Alaska (Pribilof Islands)

- 500 people; $0.50/kWh w/o Subsidy
- 1999: Wind-Diesel Twinning (*Jumelage*)
- 1 Used Vestas V27 225 kW
- No Batteries
- 27,000 L Thermal Storage
  Load Used to Regulate Frequency
- **Synchronous Generator**

Paul Gipe, wind-works.org
Saint Paul, Alaska (Pribilof Islands)

- 2007: Added 2nd Turbine
- Diesel
  - 2 x 150 kW
  - Cut Consumption 50%
- Currently: 3 Wind Turbines
- Periodic 100% Wind

Paul Gipe, wind-works.org
Special Applications
Off-the-Grid Homes

• Wind, Solar PV
• Backup Generator
• Storage Batteries

Paul Gipe, wind-works.org
Telecom Hybrids

- Wind & Solar PV
- Backup Generator
- Storage Batteries
Wind & EVs

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2008, Tehachapi, California
Wind & EVs

- Marriage Made in Heaven
- EVs Are a Disruptive Technology

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2005, Vienna to Denmark in an EV!
EVs: Distributed Storage

- ILSR: Distributed Storage Makes Distributed Generation More Valuable
- Micro Grids with Sun, Wind, & EVs
- More Comprehensive Solution
- Use More Generation On-Site!

Paul Gipe, wind-works.org
Hybrid Wind & Solar: Hourly

May 9-11, 2014: % production PV, Wind, [PV + Wind]. Source of data: EEX

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Hybrid Wind & Solar: Monthly

Average Daily Productivity Nhd on 2 years (1/12 to 12/13)

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Storage

The storage problem is solved - technically
Gas storage is unique with storage capacity

Source: Sterner, Stadler, 2014
Prof. Dr. Sterner, OTHR, S. 6

Paul Gipe, wind-works.org
Germany Need for Storage

• Not Needed for RE <60% of Supply
• Storage?
  - Hot Water for District Heating
  - Wind-to-Gas
• Germany Has 220 TWh or NG Storage
• ~4X 60 TWh Storage Needed for 80% RE in Electricity

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Hybrid Power Systems

- Nothing New
- Exist in All Sizes
- Use a Mix of Resources

It’s All About the Mix

David Nixon displaying a micro wind-solar hybrid at the Kortright Centre, Ontario

Paul Gipe, wind-works.org
• Hourly production of wind and solar in Germany. The generation from wind and solar together smoothes out the hourly fluctuations from each technology individually. However, during these three days in May 2014, wind was far less variable than the predictable variation in solar. (Bernard Chabot)
• Average daily productivity of wind and solar in Germany for 2013. Though wind and solar vary widely throughout the day and through the seasons, combined they offer a much smoother form of generation than either alone. To minimize integration costs, it’s necessary to optimize the proportions of each technology on the system. (Bernard Chabot)

Paul Gipe, wind-works.org