Renewable Energy 2.0

Transitioning From Raw Power To System Stability

A Look at the Past and Future of Renewable Energy

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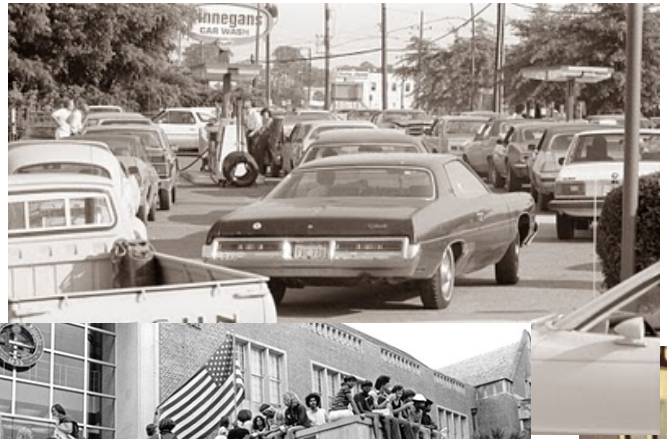
Today's Discussion…

1. ***Renewable Energy 1.0 - What We've Been Doing for the past 40 years***

2. ***The Problems That Still Exist***

3. ***Renewable Energy 2.0 - Solutions That Lead to Greater Sustainability***

I'm a Child of the 1970's…

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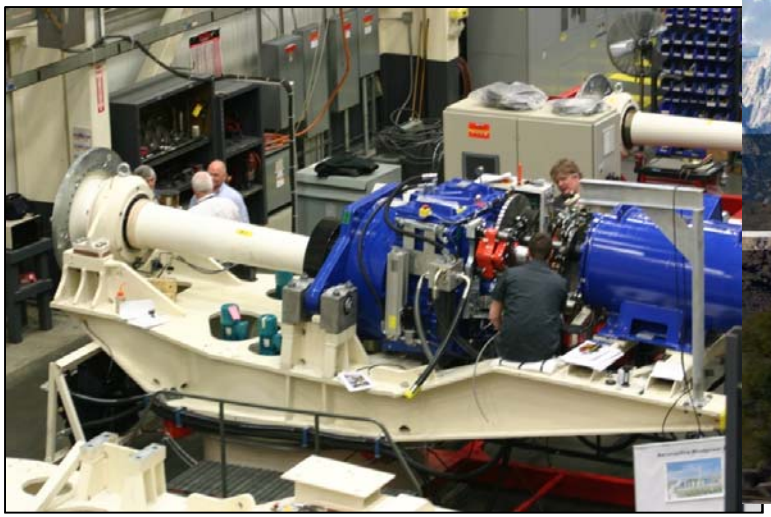
A-PLANT MISHAP LEAKS RADIATION

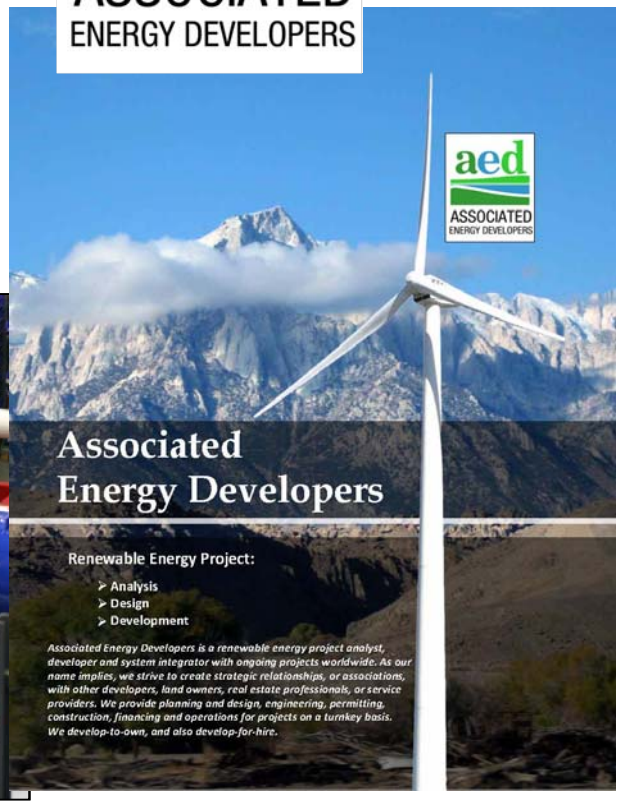
Contaminated steam escapes in Pa.

Now that my hair is White…

- **UMass machine is in Smithsonian Institute**
- **Founder, Principal in Two Renewable Energy Companies**
  - **Aeronautica Windpower, LLC -** a US-based (Massachusetts) wind turbine OEM of 250, 750 and now 2,000 and 3,000kW
  - **Associated Energy Developers** - Project Analysis and Development company offering **Solution** Integration for Renewable Energy projects.

"Perspective…"





Renewable Energy 1.0 - The past 40 years.

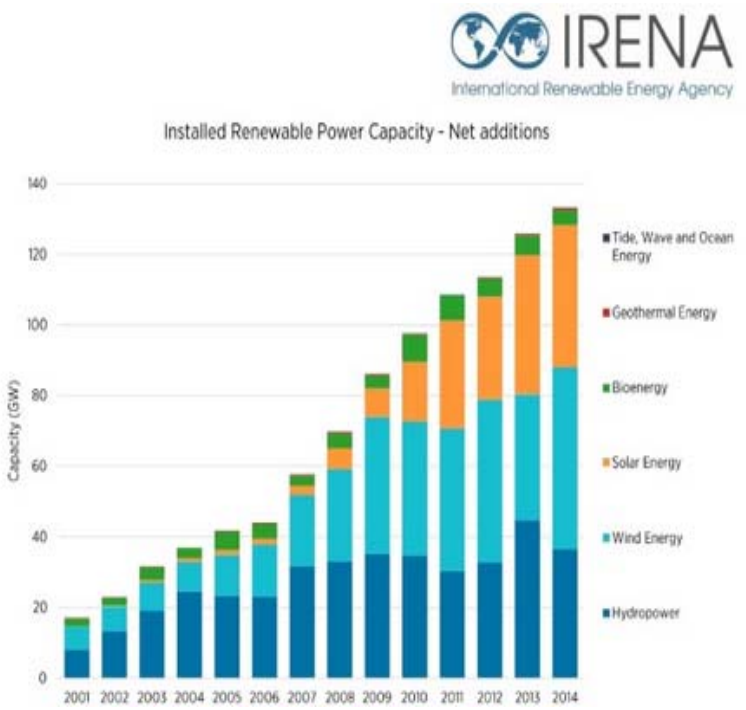
Period marked by:

•Good Growth of Wind and Solar due to Public Conscience – CA now 24% renewable. Germany, MA successes. Unheard of 30 years ago.

•Solid Product Development – we've learned what works and does not work for long periods of time. Prices dropped.

•Resistance to DG RE by Utilities forced to accept IPPs and Deregulation, but gradually improving as they learn RE works.

•Policies and Regulations which reward kWhrs and Investment (ITC) without regard to Timing or Stability of Power. OK when amounts of energy being injected are small % of grid. PROBLEMS AS % GROWS.



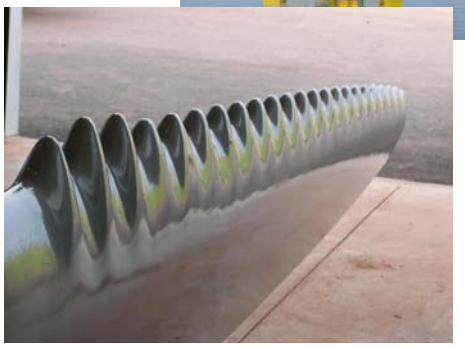
The Problems That Still Exist (as I See Them)…

1. Attractive Financing Vehicles for DG projects. Still harder to finance a $1M project than a $10M project. Encouraged by new Yield Cos.

2. The current 'round-about' way of attributing value to the environment via support through the RPS (RECs, Feed-In Tariffs, etc.). Still seen as 'subsidizing' RE when we should be charging Fossil Fuels with the cost of polluting and cleaning the environment instead of rewarding renewables. *Can't even have the discussion unless you assign the environment VALUE.*

3. Improving the STABILITY of power coming from Wind and Solar through STORAGE methods and integrated systems:

- **Long-Term (think islands and resorts)**
- **Short-Term (think hours and supply shifting)**
- **Sub-Second (think about the X^3 of wind power)**



Some continued technology improvements?

Renewable Energy 2.0 - The next 20 years.

Integrated Solutions – *combining the Prime Mover with short, near and long term storage.*

A different SYSTEM mind set…

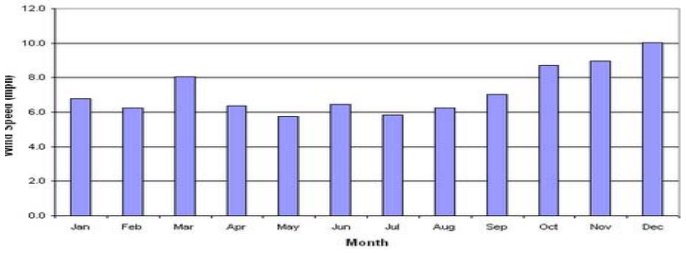
- Energy efficient – INTEGRATED - design
- Short, Near and Long Term Energy Storage
  - Regenerative Brakes
  - Computer regulated power
  - Battery Storage
  - Long Term Chemical Storage

Vs.

Solutions Being Commercialized…

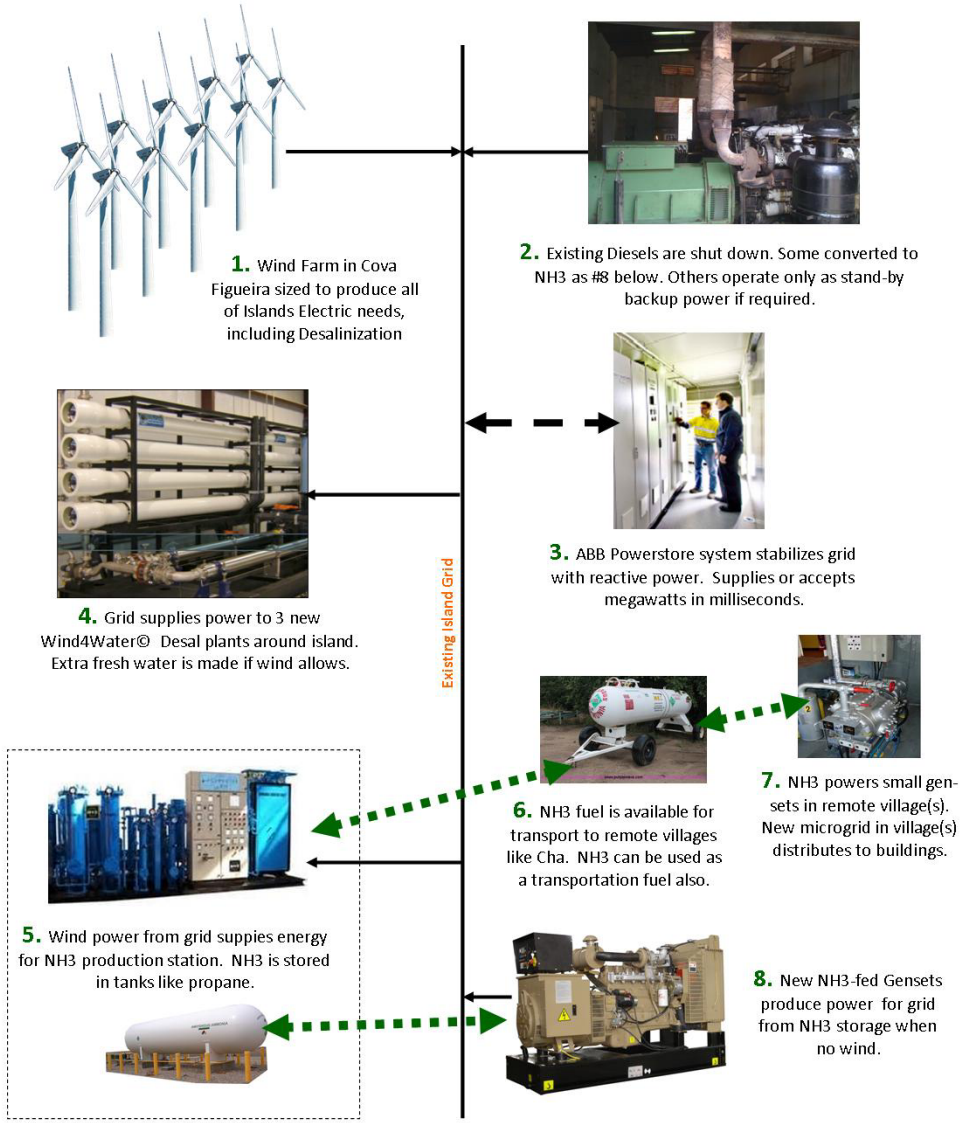
Long-Term (think islands and resorts)

- **Pumped Water Storage (Over 80GW)**
- **Larger Ganged Batteries**
  - Flo-Batteries
  - Li-Ion
- **Chemical Storage**
  - Hydrogen?
  - NH3 (the other Hydrogen)
- Others (CAS, etc.)



Long Term Chemical Storage (NH3) to Provide 100% Penetration

- AED has designed renewable energy systems for islands to allow **100% operation** using renewables.
- Purposely oversized Wind or Solar farms result in excess energy which is **stored in form of NH3** (Anhydrous Ammonia) like propane.
- When wind and solar lulls occur, **NH3 can be burned** in modified diesel engines to produce power.
- Result is that islands can use a stored form of renewable energy to **become 100% sustainable.**
- Short-listed on 2 grant awards for this concept.

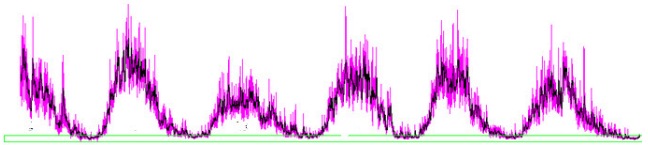


Integrated Fresh Water Production

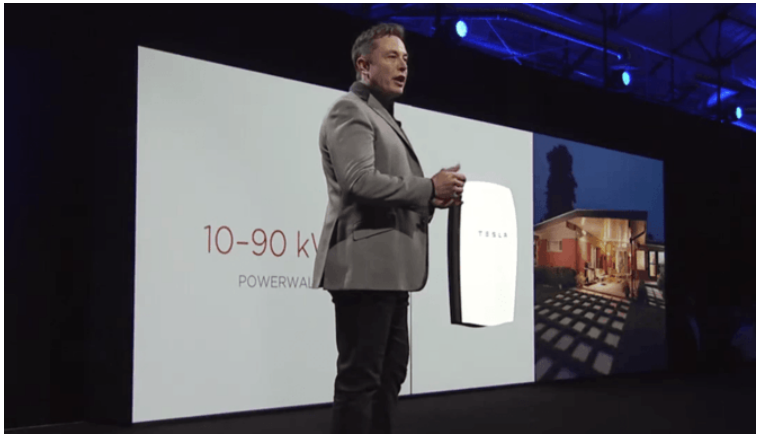
- Solution inherently solves problem of power fluctuations and energy storage. **Excess wind energy stored in form of inexpensive water**.
- This 'dump load' maintains energy value, allows integrated systems to be designed. AED pre-configures systems so they are **easy to specify**.
- Water production is electricity intensive - wind generated water can be produced for less than diesel driven power, so **water costs less**. Perfect for island nations.
- **'PV4Water©'** on same concept.

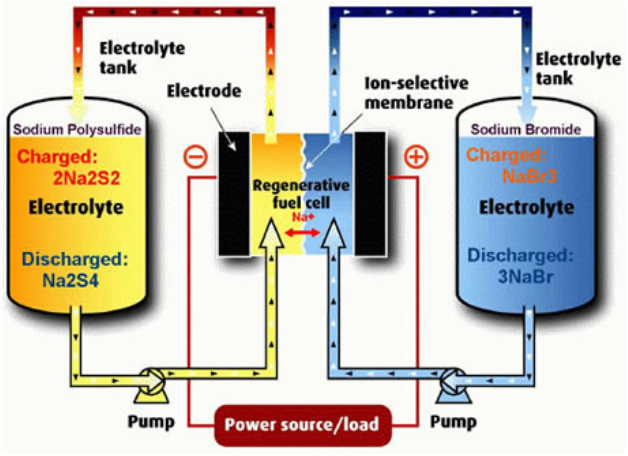
Solutions Being Commercialized…

Short-Term (think hours and supply shifting)

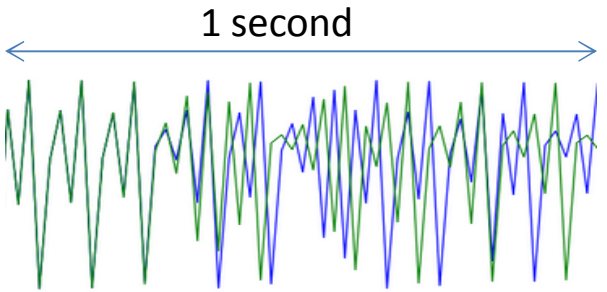


- **Prized by Utilities**
  - 4 – 6 hours shift into evening does a LOT!
- **Dominated by Batteries**
  - Lithium Ion (Musk, etc.)
  - Flo-Batteries
- **But** also accomplished by larger storage as well, such as PW, Chemical, etc. on Utility scale





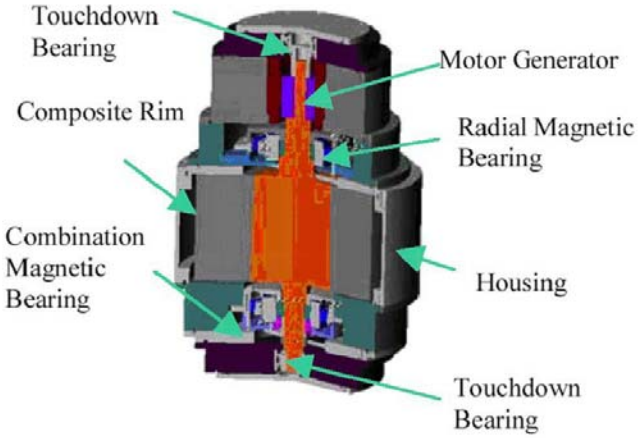
Solutions Being Commercialized…



Sub-Second (think about the X^3 function of wind power)

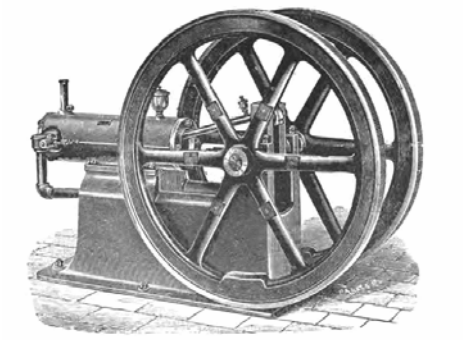
Q. If a 1/4 second gust of 2x wind occurs, and I get 8x the power, where does the energy go?

A. It drives the grids crazy and trips protective grid relays. Sub-second (cycles) problems. This is why large scale integration of renewables is hard on a grid operator, and they give up at 10-20% integration.



Solutions:

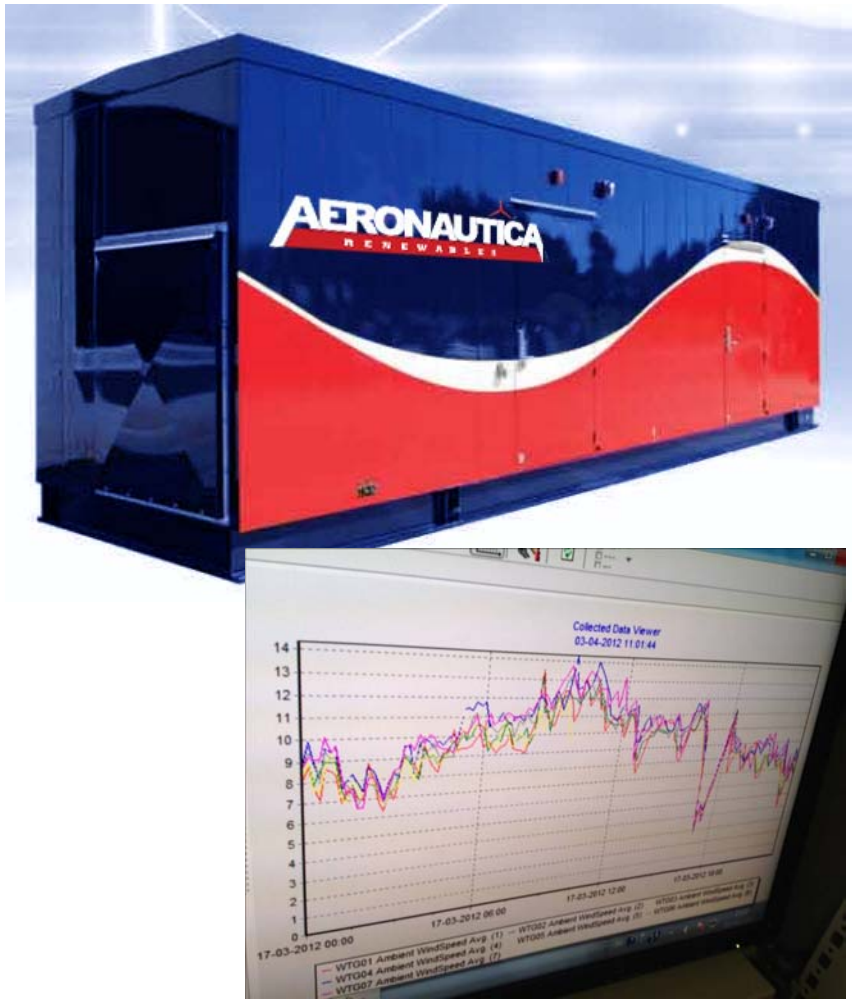
- **Flywheel Storage**
  - Accepts or Rejects Megawatts in Milliseconds
  - Flywheels are what make diesel gensets WORK – they provide ***System Inertia***
  - Smoothes out power fluctuations
- **Some Flo-Batteries**
  - Batteries in general don't take varying current well…



AERONAUTICA WINDPOWER

200kW – 2MW Flywheel and Flo-Battery-based Electrical Storage Systems

- These Flywheel and Flo-Battery systems **smooth out the rapidly fluctuating power** of wind and solar projects.
- Storage allows both **STABILIZATION** and short term **ENERGY SHIFTING**, greatly improving the value of the power to local users and utilities.
- Members of AED Technical Board are world-renowned experts at this technology.



Who Pays?

We've become used to dumping raw power into the grid at profitable rates to get RE kick started – and it has worked.

Q: But for RE 2.0 and the future, who pays for the Stabilization and Storage?

- •Grid Operators?
- •IPPs?
- •New 'Power Storage Companies'?

A. Consumers

Regardless of who it is, there is a cost involved that must be integrated into the price of energy in order to attain long term acceptance. And it is associated with the variable nature of renewables, so we (industry AND society) need to look at INTEGRATED costs and benefits.

Renewable Energy 2.0

Transitioning From Raw Power
To System Integration

A Look at the Past and Future of Renewable Energy

Thank You

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