Hydrail: Switching Onto Track

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10th International Hydrail Conference

Charlotte, NC

2015 June 22

Why now for Hydrail?

- GHGs and climate change finally getting broad political recognition
- Early responses introducing new low-C technologies have led to disruption of the electricity market
  - Demand always varied, but predictably
  - Supply now varies too and frequently unpredictably
  - Value of generated electricity now varies wildly
- Makes hydrogen a distinctly attractive way of storing electrical energy
  - Shifting energy from troughs of low demand to high-demand peaks
  - Fuel cell technology has matured—a type of flow battery

Fuel-cell propulsion for trains is REAL

2015 May 27: Hydrogenics and Alstom Sign Agreement to Develop and Commercialize Hydrogen-Powered Commuter Trains in Europe.

- Hydrogenics Corporation, a leading developer and manufacturer of hydrogen generation and hydrogen-based power modules, today announced that it has signed a 10 year exclusive agreement to supply Alstom Transport with hydrogen fuel cell systems for Regional Commuter Trains in Europe. … The agreement, valued at over €50 million (56 M$), includes the supply of at least 200 [fuel cell] engine systems along with service and maintenance as necessary over a 10 year period. Hydrogenics was selected by Alstom following a rigorous technical review process.

Fuel-cell propulsion is hugely competitive

Christian Wolmar—a rail transportation expert—quoted by the BBC estimates that 1 billion pounds (1.6 G$) would electrify 125 miles of (existing) rail track—2015 April 16.

So Hydrogenics 200 fuel cell engine systems cost the equivalent of electrifying <5 miles of track.

The energy input for hydrogen to fuel cells exceeds direct electricity. However, producing hydrogen with off-peak power can provide a mighty cost offset. Electrolysis hardware (+20%) and hydrogen storage will easily be absorbed without upsetting the economics.
***And hydrail can go anywhere*.**

Why focus on trains?

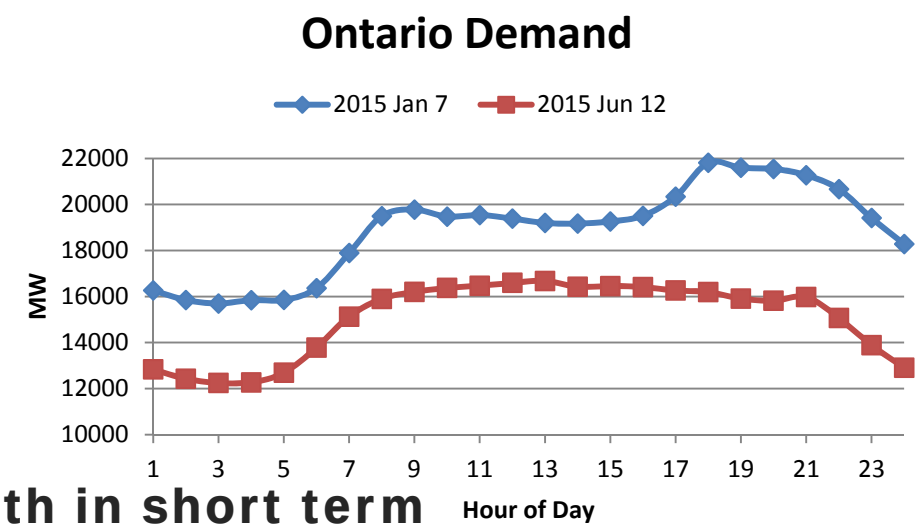
- A transport revolution is underway
  - Cities are being pressed to provide commuter transit
    - Need to do it in low-C ways
  - ***BUT:***
    - Track electrification is very expensive and disruptive to install
      - For long hauls, N. America lacks Europe's density
    - Electrified track demands power ***NOW***—often at times of peak demand
  - ***HOWEVER:***
    - Hydrail avoids both drawbacks
      - Far less capital and shifts load to off-peak supply
- Much easier than road transport with its fuel supply problem

Climate change mitigation

- **To stabilize the atmosphere, we need an 80% reduction in GHG emissions**
  - ***Half-measures are insufficient and potentially distracting***
    - ***e.g. Substituting gas for coal***
    - ***Relying on improved energy efficiency***
  - ***Switching to rail with its intrinsic lower energy use is in itself desirable but needs a low-emission energy source***
    - ***i.e. electricity from a low-C source***
      - ***nuclear, wind, solar***
  - ***Electricity deployed as hydrogen, as Hydrail is clearly superior to track electrification***
    - ***Can accommodate the rise of fickle new renewable generation sources***

Demand and supply issues

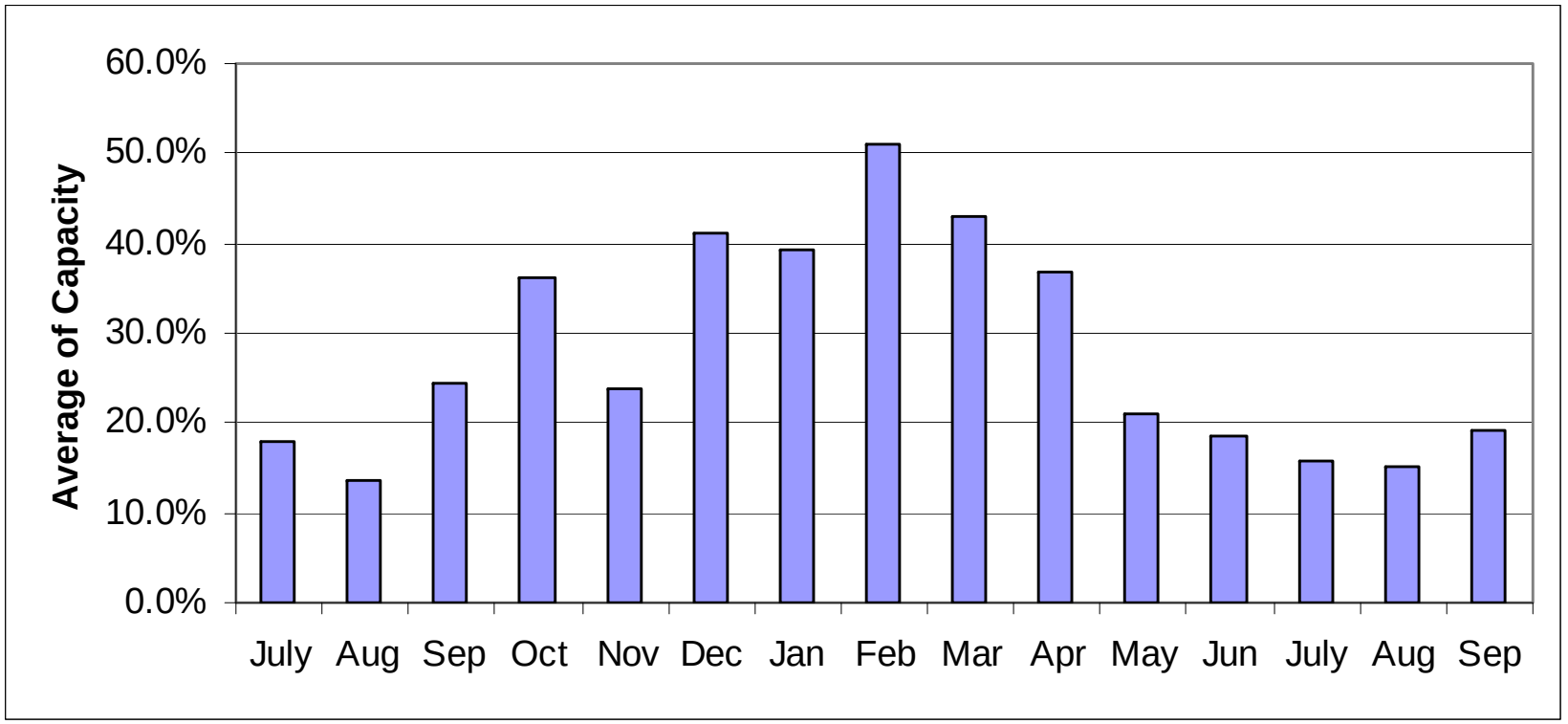
- **Demand is very variable**



- **Wind is highly variable both in short term and seasonally**
- **Solar is also highly variable though its seasonality tends to mirror that of wind**
- **Nuclear is designed to operate continuously at full power**

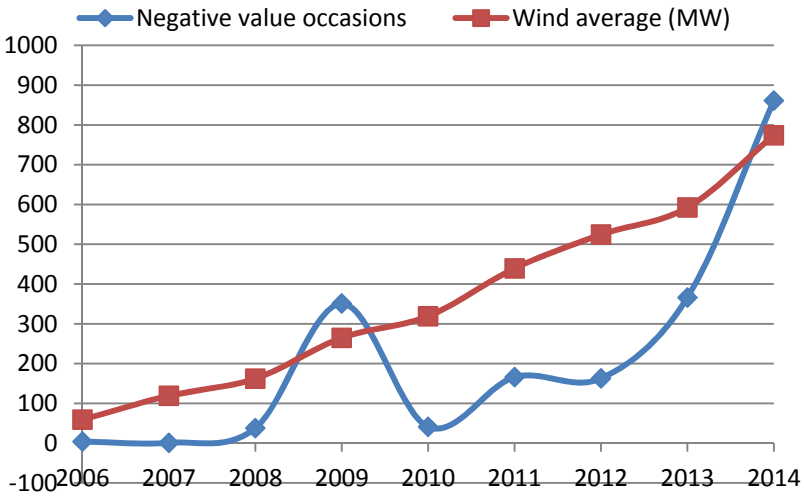
Utilizing wind is complicated

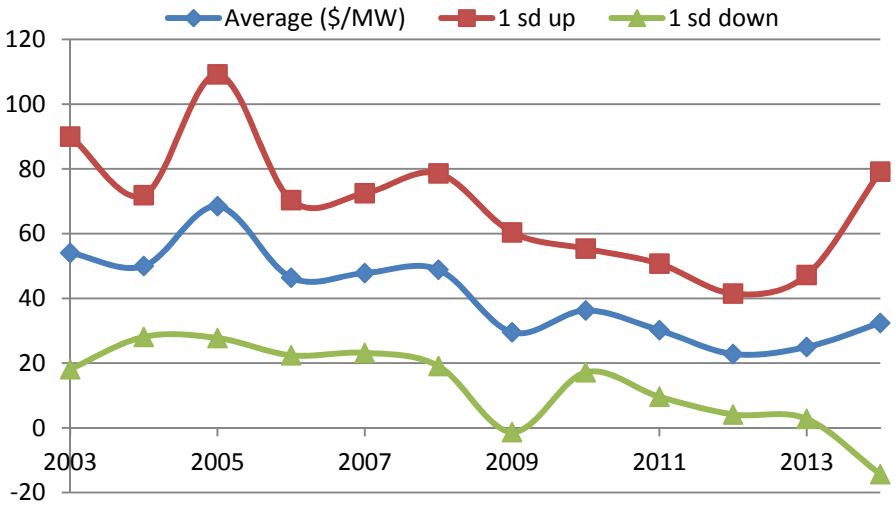
- Wind energy is not only erratic but also seasonal



Intrinsically expensive & market disruptive

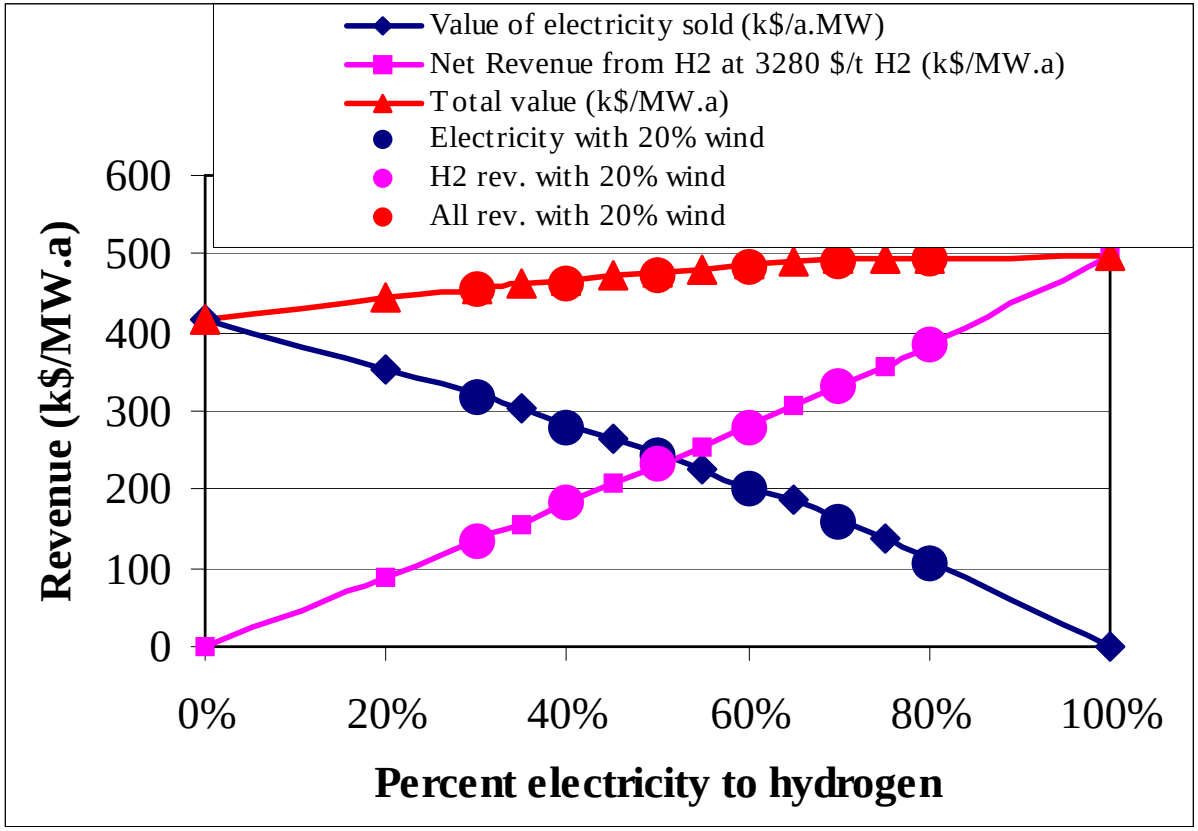
Windpower can have substantial adverse on electricity value … and it's not all upward (Ontario grid)





Actually enhances opportunity for hydrogen production off-peak

NuWind™ : 20% wind and 80% nuclear blend easily with intermittent conversion



- Variable cell current accommodates wind's fluctuations
- System has a much higher proportion of time on-line than wind alone

Using co-incident Ontario grid prices and wind data, H_2 cost is almost indistinguishable from nuclear alone

Which transport form for H_2-power?

Feature	cars	truck	plane	train	ship
• Few operators	1	2	4	5	3
• High utilization factor	1-2	4	4	4-5	5
• Steady load	2	3	2-4	3	5
• Not too dispersed	1	2-4	4	5	3-4
• H_2 volume unimportant	1	3	3	5	5
• Weight important	3	3	5	1	1
• Good control of H_2	1	2	5	5	5
• Minimal public anxiety	1	4	1	5	5
• TOTALS	11-12	23-25	28-30	33-34	32-33

Trains first; other modes can follow

The hydrogen age has begun!