Hawaii's Clean Energy Challenges

HEPF
May 27, 2016
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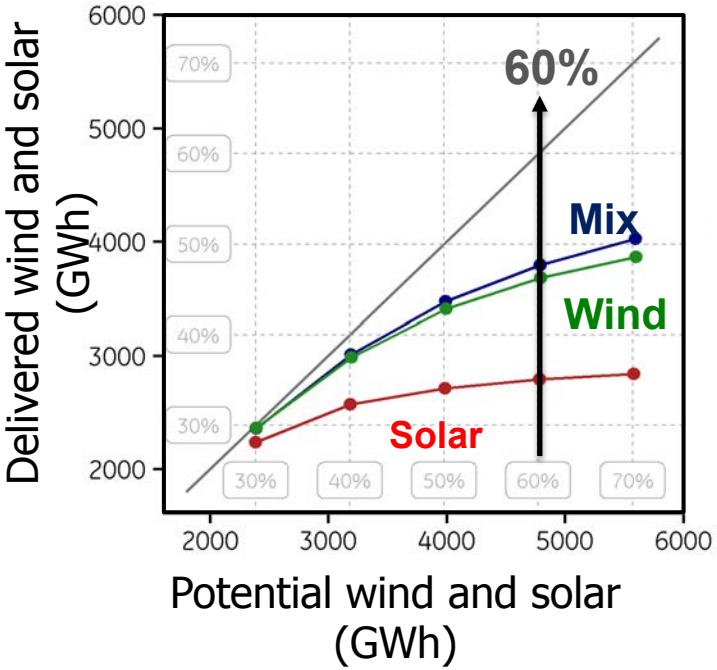
The RPS Challenge

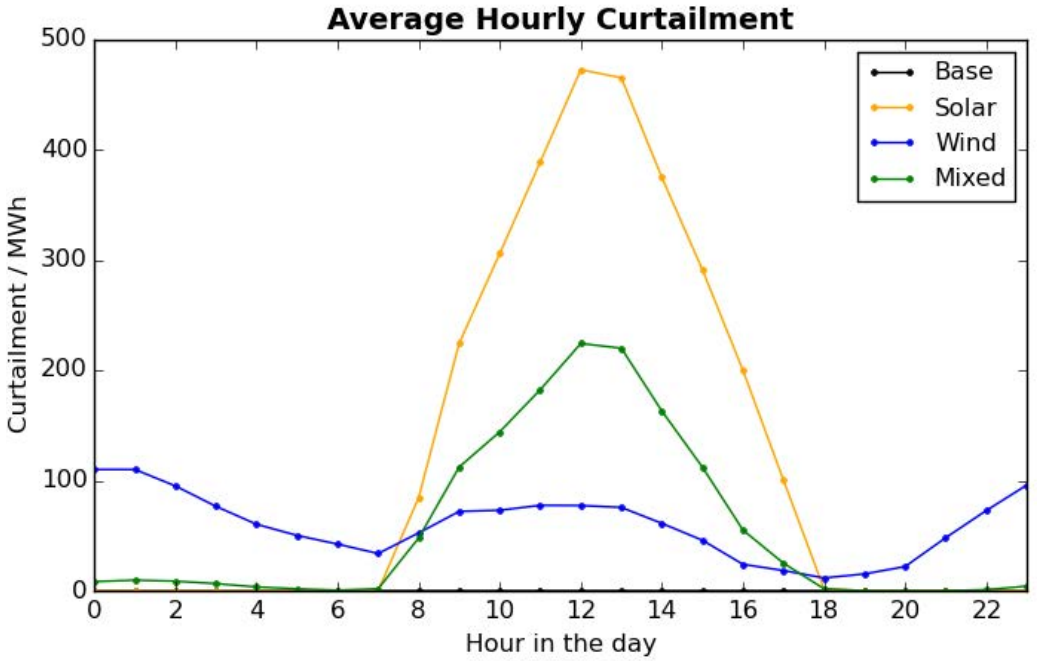
- **"Near" future Oahu renewables estimate**

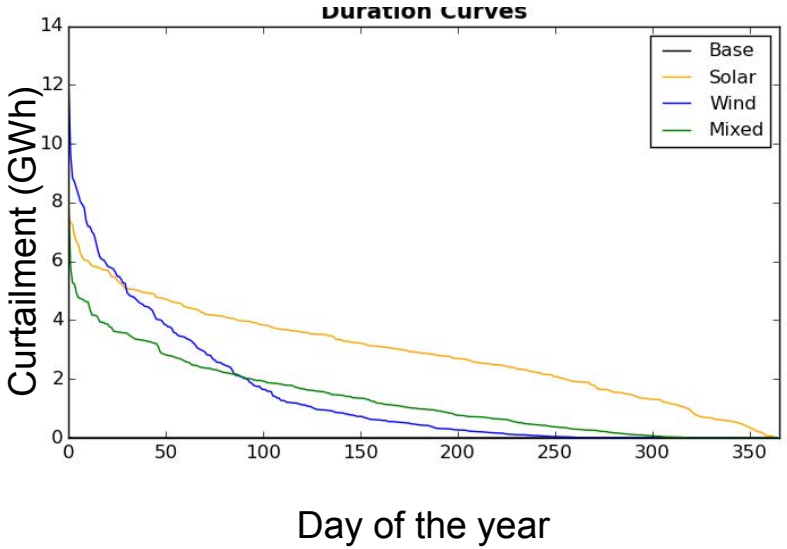
125 MW Wind	~383 GWh (4.9%)
375 MW DPV	~591 GWh (7.6%)
152 MW CPV	~293 GWh (3.8%)
69 MW Waste	~ 390 GWh (5.2%)
120 MW Biofuel	~ 36 GWh (0.5%)
Total Renewable	~1693 GWh (~21.8%)

- **Oahu (72% of state total) currently gets ~ 11% from wind and solar. Optimistic penetration by 2017 around 15% from wind and solar.**
- **Options to 100% include**
  - Significant growth of wind and solar (Oahu or "offshore")
  - Biomass and biofuels
  - Geothermal with cable
  - Still emerging technology (wave, OTEC, ?)
- **Potential pathway to 100% renewable:**
  - Assume we find 30% firm, "dispatchable renewables" e.g biomass, biofuel, geothermal, OTEC
  - Grow balance from solar and wind (numbers below based on available energy)
    - High solar: 2,800 MW additional solar (10 -50 sqmi)
    - High wind: 1,600 MW additional wind: 800 – 2MW turbines, (~60 sqmi)
    - Mixed W&S: 1,540 MW additional solar, 960 MW additional wind

Curtailment at High Penetrations (Oahu)







- **Incremental (marginal) curtailment increases significantly at high penetration**
- **Complex curtailment (hourly and daily) requires flexible mitigation measures**

Integration with Electric Transportation

- **Potential pathway to 100% renewable electricity plus 40% ground transportation :**
  - Assume 30% electric from firm, "dispatchable renewables"

  - **EV (@ 100 miles/24kwh)**
    - High solar: 3760 MW additional solar
    - High wind: 2100 MW additional wind: 1000 – 2MW turbines

  - **H2 by electrolysis (@2.5x efficiency of current vehicle fleet)**
    - High solar: 5530MW additional solar
    - High wind: 3160 MW additional wind (1500 – 2MW turbines)

Closing Comments

- Moving beyond 30-40% will require very creative system integration and new innovations (curtailment, reliability, stability)
- Required renewable energy development is immense and generally underestimated: land use/siting; community impact; community acceptance, multibillion dollar investment
- Optimal path forward is dependent on future costs of renewables and mitigation measures – many rosy predictions, lots of uncertainty.
- Current obsession with low-cost pathway to 100% is distracting from work needed to increase renewables usage using 'real' costs.
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    - **Can the community come together with a definitive plan to double what we have today**

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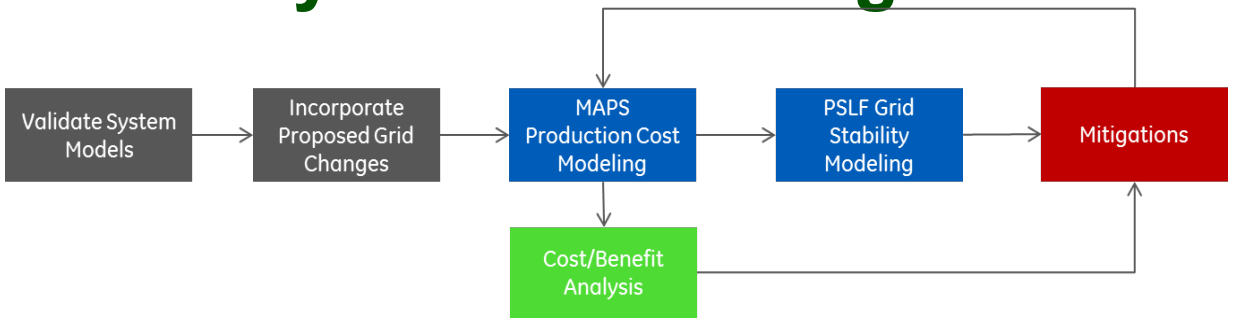
Power Systems Modeling for Planning



- **Quantify impact of new energy systems on production cost and curtailment**
  - Different resource mixes (wind, central and distr PV, other)
  - Alternative fuels (LNG, hydrogen, biofuels)
  - Grid configuration (independent or connected)
  - Changes due to load and load-profiles (end-use efficiency, alt transportation)
- **Analyze reliability and stability** – quantify additional mitigations
- **Identify and quantify mitigation methods to address curtailment, reliablity and stability**
  - Advanced controls, unit cycling, reduced minimum run, improved forecasting
  - Energy storage, smart grids, advanced inverter technology, microgrids, demand response, integration with transportation
- **Evaluate cost** - grid changes, mitigations, transmission and distribution upgrades