NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Hybrid Power Plants Challenges and Opportunities

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Topical Experts Meeting – Day 3 – August 26, 2020

Why Hybrid Power Plants

- Enhance flexibility of renewable generation
- Provide reliability for the grid of the future

Challenge: Highly complex systems that must be customized to a given application

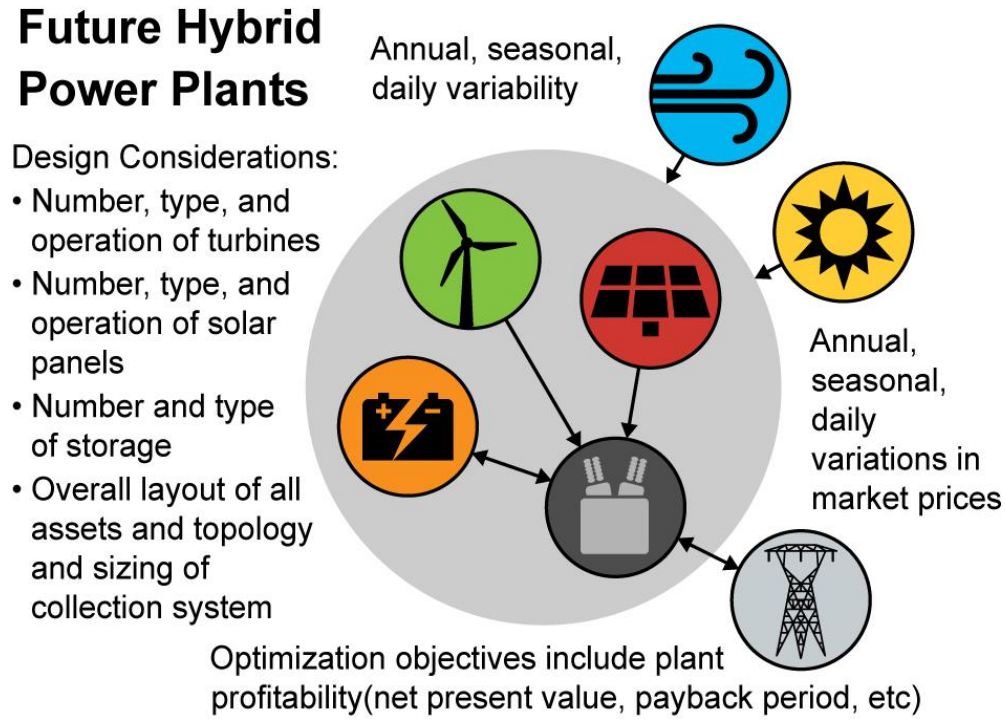
Goal of this Meeting

Overall: Accelerate the development and deployment of hybrid power plants

- What are our biggest roadblocks?

- **Topical Experts Meeting (TEM):** If this were to become an IEA Task
  - Determine areas of international collaboration
  - Determine the role of this task

- **Critical Areas:**
  - Benefits of hybrid power plants
  - Microgrids and control
  - Sizing/Optimization and Storage solutions



Day 2 Recap – Microgrids and Control

Microgrids

- **Peter Lillenthal** – HOMER Energy
  - Hybrid Optimization for Multiple Energy Resources (HOMER) - system sizing, 1 minute resolution, economic value
  - Microgrids/Front of the meter systems
- **Ian Baring-Gould** – NREL, IEA Wind Task 41
  - Distributed wind, MIRACL, control of power systems with BTM systems
  - Need demonstrations that these can work in the real-world
- **Reo Kontani** – Hitachi
  - Presented several case studies for HPP due to wind unevenly distributed in Japan and high costs of installing wind
- **Qian Long** – NCSU/DTU
  - HIL testbed for microgrids – digital twin capturing energy storage dynamics and demonstrating control of system

Controls

- **Vahan Gevorgian** – NREL
  - Several ongoing projects at NREL to demonstrate the capabilities and control of hybrid systems (Flexpower)
- **Parangat Bhaskar** – NREL
  - Impact of flicker on solar panels including raw power lost and decreased power quality
- **Andreas Rettenm**eier – ZSW
  - Demonstration facility that has been used for wind – could potentially be used for HPP

Research Priorities – Drive Breakout Session

Day 3: Sizing/optimization and Storage

- Storage solutions to consider for HPP
- Combined storage solutions
- Most important design considerations in HPP (DC vs. AC coupling/inverters/etc.)
- Other value streams beyond electricity
- Reference hybrid plants (how to address high degree of customizability)
- How to design for operation (minimize size of storage)
- Optimization needs (derivative free, gradient-based, how to handle scale of problem)

What can we do in an IEA Hybrids Task?

Agenda

Day 3: Sizing and optimization (Jennifer King, NREL)

Recap

5:00 – 5:10am – *Recap* from Day 2 and relevant survey results (Jennifer King, NREL)

Technology Snapshots

5:10 – 6:20am – *Technology talks* from experts on sizing and optimization of hybrid power plants (10 min each)

- Katherine Dykes – Technical University of Denmark
- Kate Anderson – National Renewable Energy Laboratory
- Mihir Mehta – TU Delft
- Charles Tripp – National Renewable Energy Laboratory
- Caitlin Murphy – National Renewable Energy Laboratory
- Mohamad Laraki – IFPEN
- Jesper Thiesen – CONWX

6:20 – 6:50 am – Break

6:50 – 7:30am – *Technology talks* from experts on storage solutions for hybrid power plants (10 min each)

- Henry Aszklar – Carbon Sink LLC
- Lionel Perret – Planair SA
- Alavaro Fernandez – Schwungrad Energie
- Paul Lucchese – IEA Hydrogen TCP chair

Breakout

7:30 – 8:30 am – *Breakout* and reported results (Breakout chairs and notetakers)

Wrap up

8:30 – 9:00 am – Wrap up from the TEM and next steps (Katherine Dykes and Jennifer King)

Main Takeaways From Breakouts

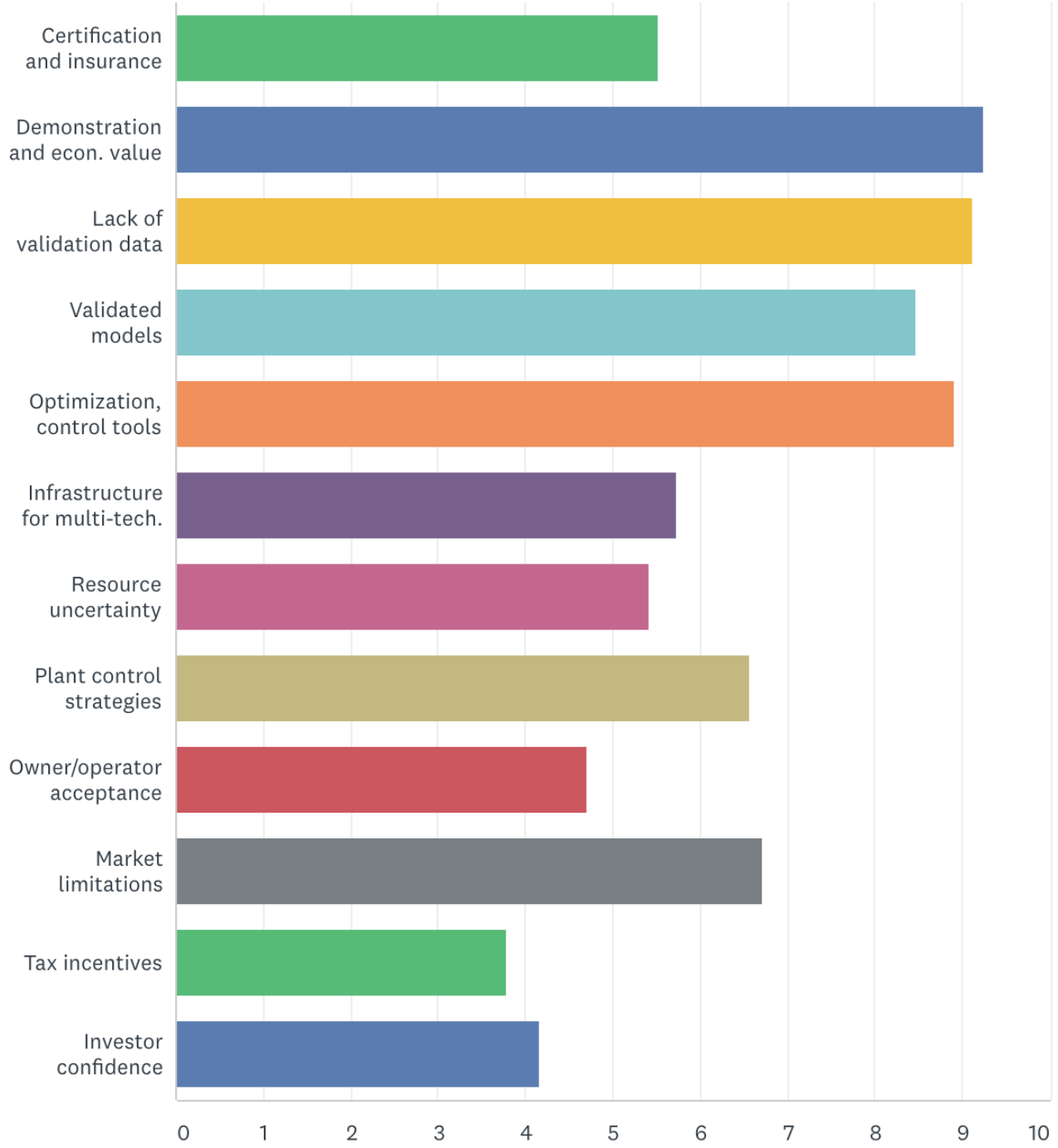
- From an IEA Hybrids Task – What is the **valuation** of hybrid power plants? Put another way, what is the **competition** to hybrid power plants, what is it replacing?
- Accurate **forecasting** (at different timescales) is a key economic driver, i.e. the better your forecast and better your controls are the smaller you have to oversize technologies including storage
- From an IEA Hybrids Task – we need **standardization** of language. What should HPP be providing
- How can grid operators **use these hybrids effectively**

Survey Results

Main Barriers for HPP

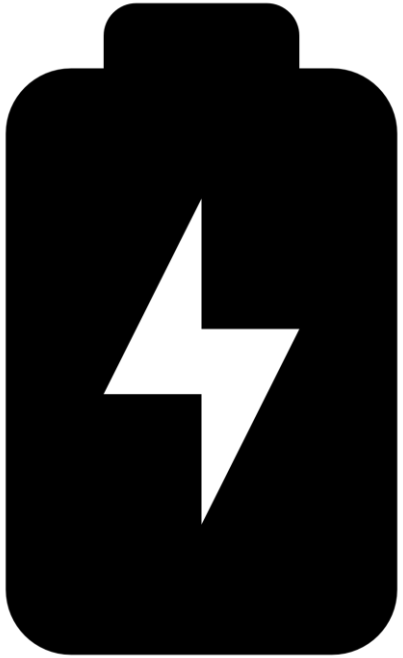
- Rank 1 through 10
- Weighted average

- Top responses:
  - Demonstration of economic value
  - Lack of validation/verification data
  - Optimization and control tools



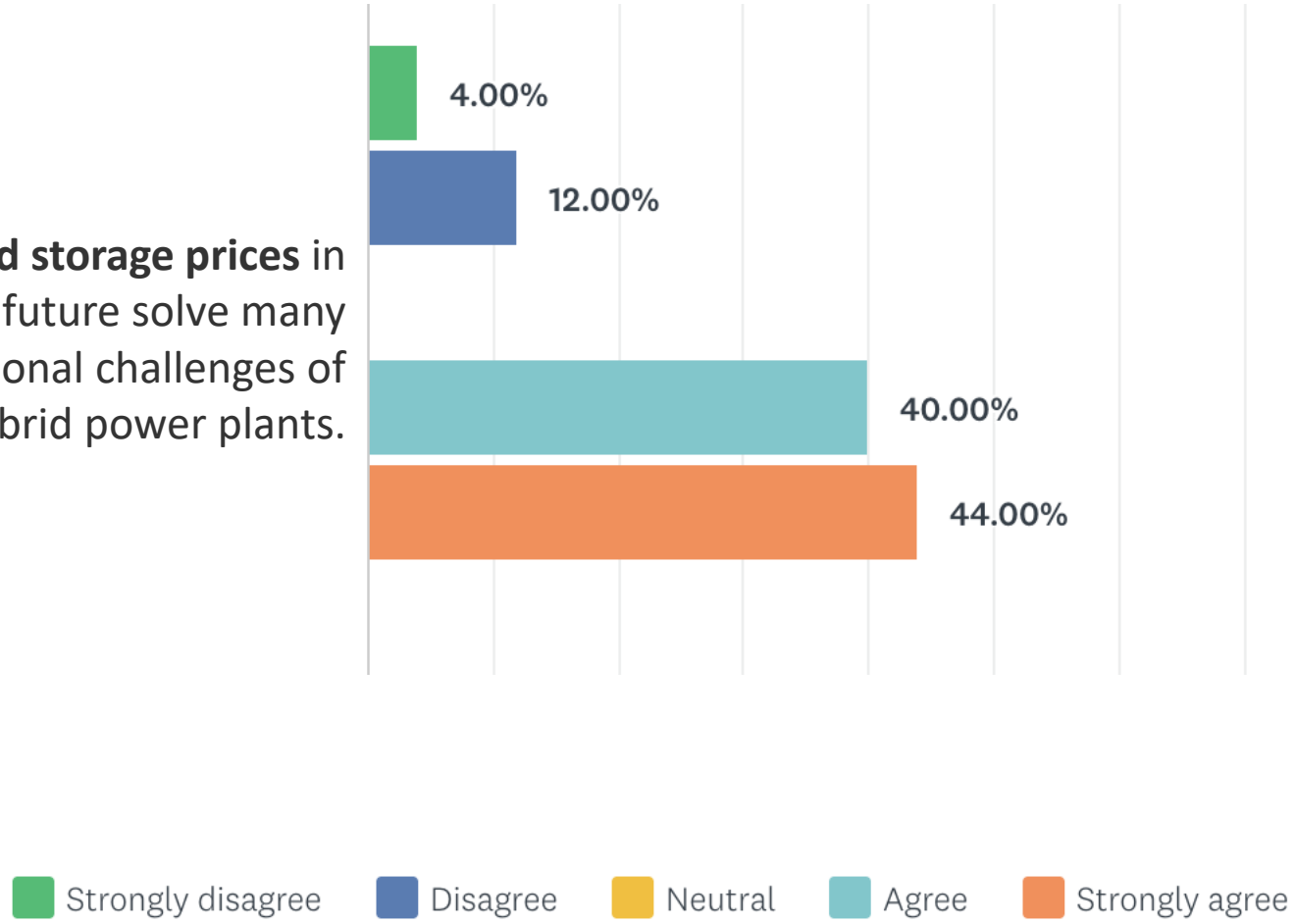
Most Promising Storage Technologies

- Lithium-ion
- Lead acid
- Flow battery
- Site-dependent
- Hydrogen
- Green Methane
- Fly-wheel
- CAES
- Redox flow
- Fuel cell
- Super capacitors
- Compressed air
- Heat storage
- Carnot batteries
- Pumped hydro storage
- Ultracapacitors



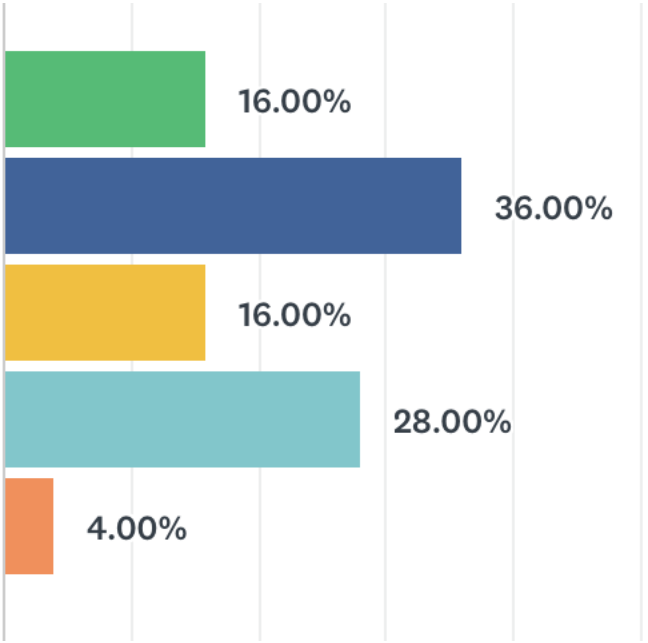
Storage

Reduced storage prices in the future solve many operational challenges of hybrid power plants.



Hybrid versus Single Technology Plants

Only hybrid power plants should be developed in the future.



Strongly disagree | Disagree | Neutral | Agree | Strongly agree