

What we need from you



Towards 100% Renewable Energy Pathways A Research Roadmap

Denver, CO
May 14-15, 2019



A report ?



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Energy Systems Integration Group

Charting the Future of Energy Systems Integration and Operations



Track 1: Adequacy

Chair: **Aaron Bloom**, NextEra Analytics

Rapporteur: **Hannele Holttinen**, IEA WIND Task 25

Location: Annex Boardroom

- Adequacy Issue Orientation: **Aaron Bloom**, NextEra Analytics

Track 2: Volts and Amps

Chair: **Jason MacDowell**, GE

Rapporteur: **Abraham Ellis**, Sandia National Lab

Location: Torrey's

- Volts and Amps Issue Orientation: **Jason MacDowell**, GE

Track 3: Distribution Systems, Microgrids and Customers

Chair: **Debbie Lew**, GE

Rapporteur: **Ben Kroposki**, NREL

Location: Ellingwood A

- Distribution Systems, Microgrids and Customers Issue Orientation: **Debbie Lew**, GE

Track 4: Flexibility, Operations and Balancing

Chair: **Aidan Tuohy**, EPRI

Rapporteur: **Chris Greig**, University of Queensland; Visiting Professor, Princeton

Location: Ellingwood B

- Flexibility, Operations and Balancing Issue Orientation: **Aidan Tuohy**, EPRI

Track 5: Markets

Chair: **Erik Ela**, EPRI

Rapporteur: **Daniel Kirschen**, University of Washington

Location: Red Cloud

- Markets Issue Orientation: **Erik Ela**, EPRI

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Research roadmap ?

*“...there are **known knowns**; there are things we know we know. We also know there are **known unknowns**; that is to say we know there are some things we do not know. But there are also **unknown unknowns** — the ones we don't know we don't know.”*

- What is education ?
- What is research ?
- What might disruption look like ?

Disruption/Game changers

- Technological advances
 - Very cheap high efficiency electricity storage is invented – this could be batteries or cheap hydrolysis
 - Very cheap high voltage transmission that can be easily undergrounded is invented
 - Renewable energy technology becomes extremely cheap
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- Architecture/institutional changes
 - All devices are connected with power electronics
 - Transactive energy becomes pervasive
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- Societal change
 - Society adapts to periods of extreme abundance of electricity and extreme shortages
 - Society accepts large scale energy infrastructure
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The Characteristics – variable renewables

- Low/no inertia
- Variable and somewhat difficult to predict
- Low capacity value
- Zero marginal cost
- Spatially disperse
- etc.

Some basic engagement rules

- Take a positive attitude, learn
- Listen actively to each other
- Ask clarifying questions
- Be aware of that many terms may have different connotations and be prepared to explain what you mean
- Try to find out where you agree with others
- Agree, to disagree; and then continue listening

Chatham House Rules

Everyone is free to repeat what is said outside this meeting, but not in a way that it can be attributed to any individual or company.

This includes all notes taken.

Speak for yourself, not your company – and have fun!

***I had the right
to remain
silent but I
didn't have
the ability***

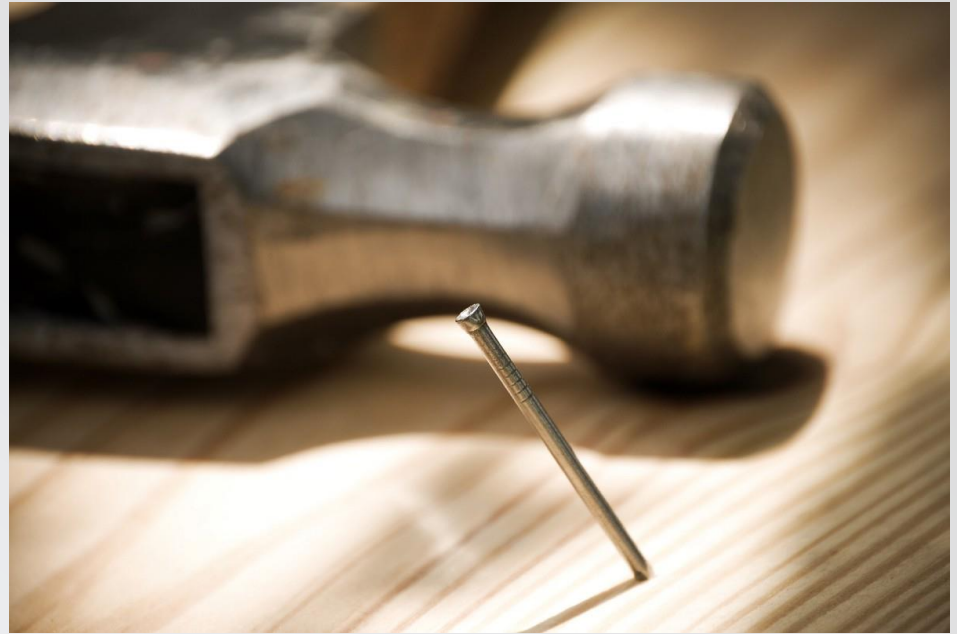
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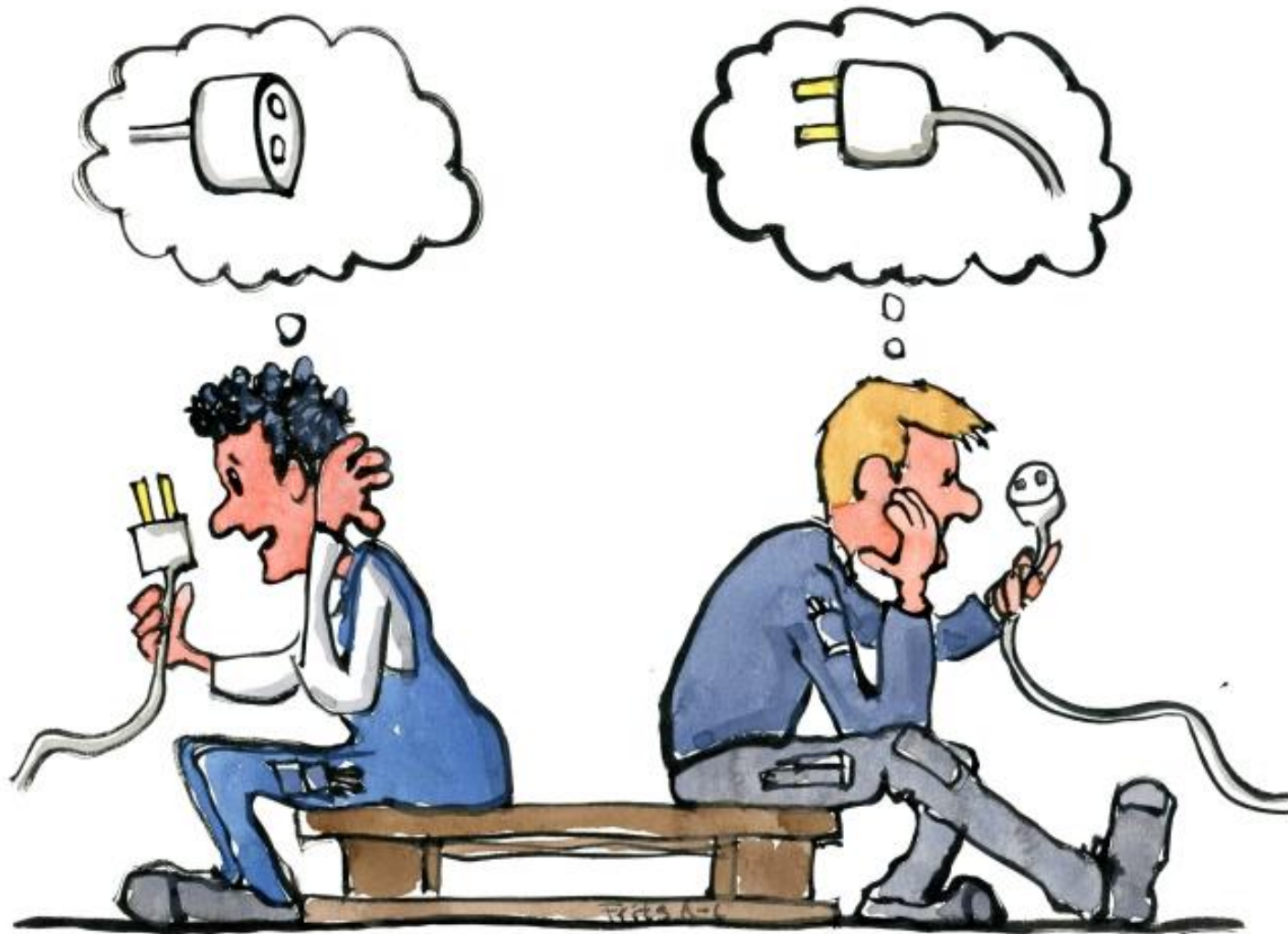
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Thank You!

Mark O'Malley

Chair Research and Education Committee

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