What we need from you

Towards 100% Renewable Energy Pathways A Research Roadmap

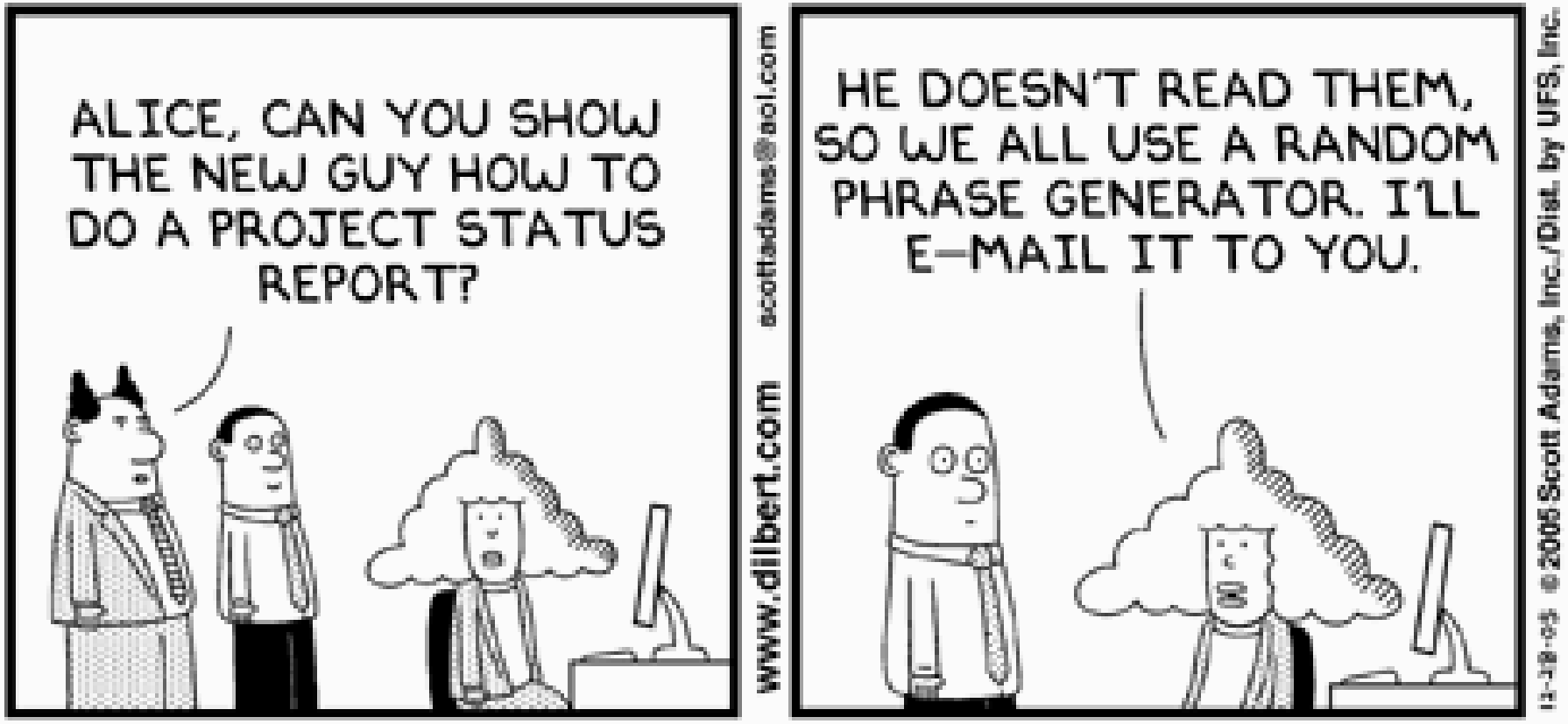
Denver, CO

May 14-15, 2019

ESIG

ENERGY SYSTEMS INTEGRATION GROUP

A report ?



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

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
  - ……
- Architecture/institutional changes
  - All devices are connected with power electronics
  - Transactive energy becomes pervasive
  - …….
- Societal change
  - Society adapts to periods of extreme abundance of electricity and extreme shortages
  - Society accepts large scale energy infrastructure
  - …….

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

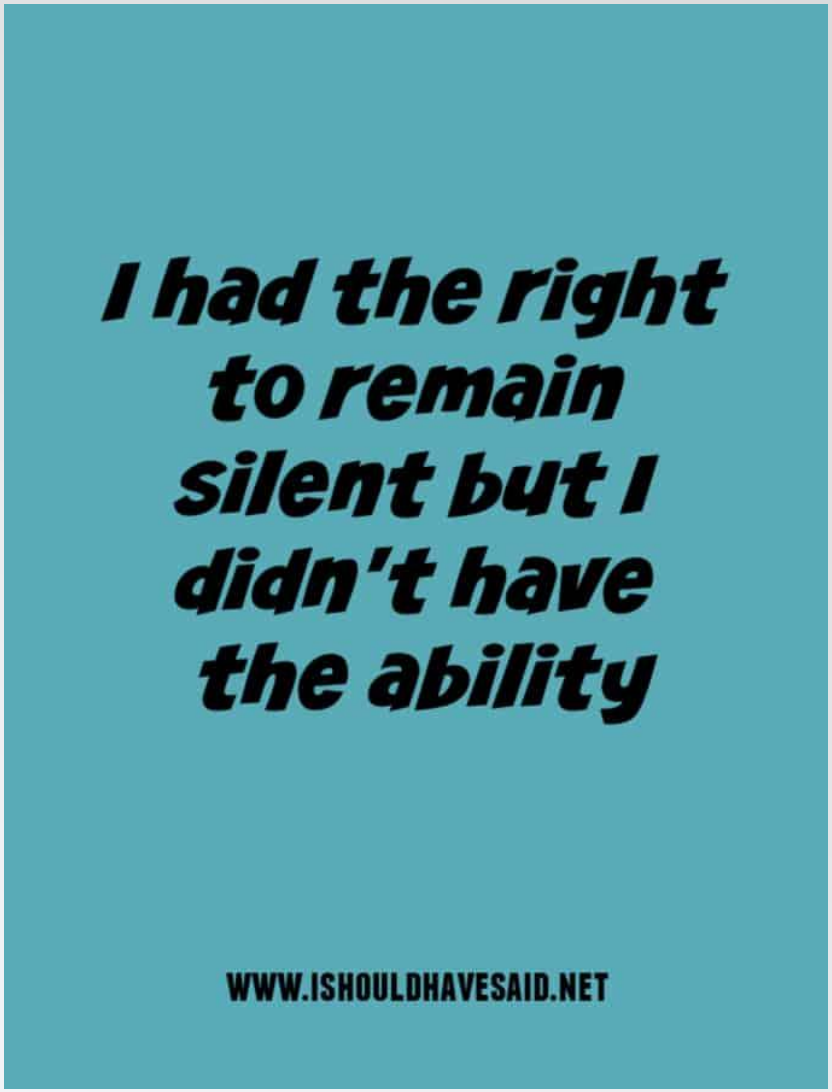
- Take a positive attitude, learn
- Listen actively to each other
- Ask clarifying questions

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.

- 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

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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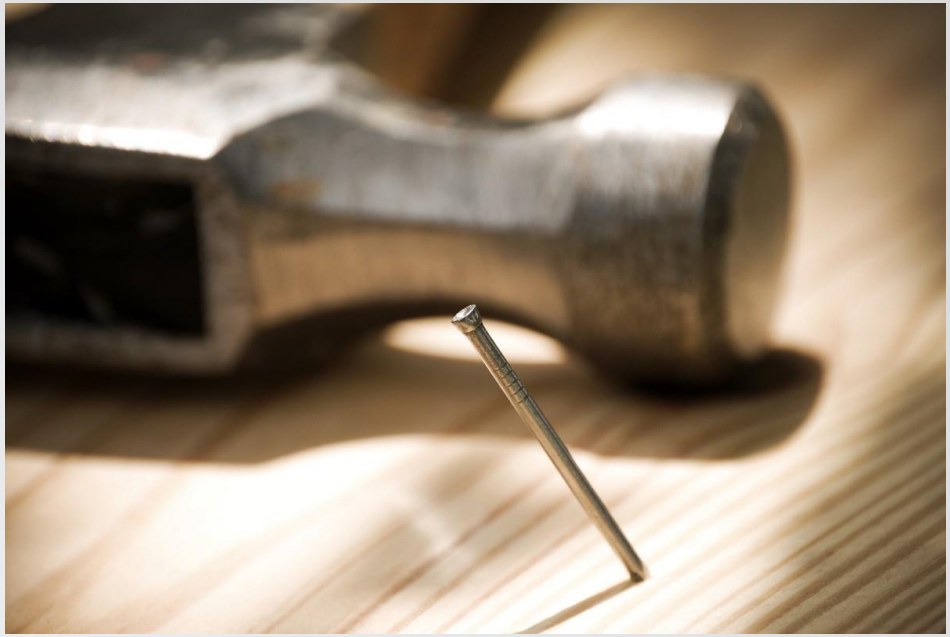
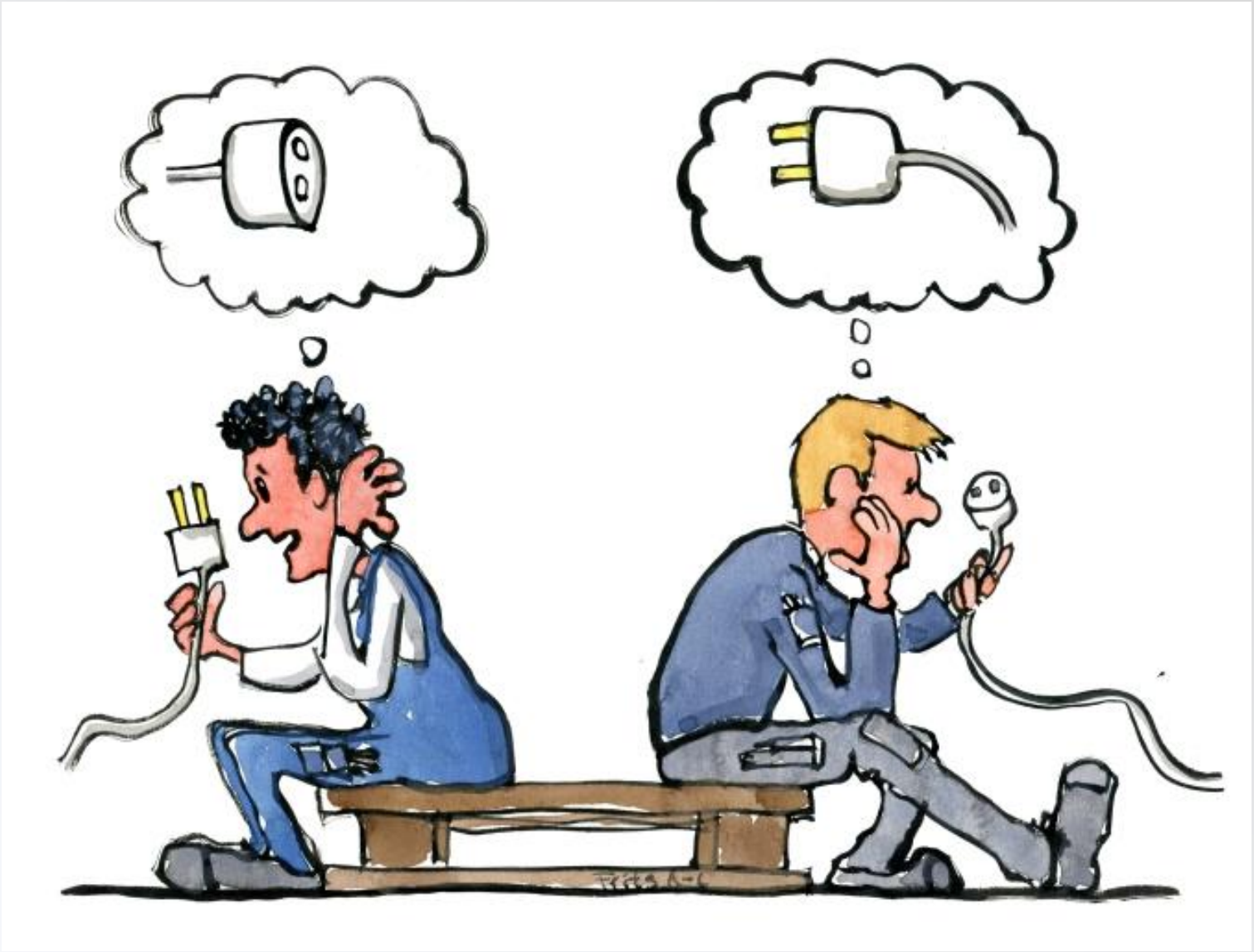
Warning





Thank You!

Mark O'Malley

Chair Research and Education Committee

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