

# IEA Wind TCP Task 43 Kickoff: Wind Energy Digitalization



**Jason Fields, National Renewable Energy Laboratory**

IEA Wind TCP Task 43 kick-off, Boulder, CO USA

Nov 5, 2019



**iea wind**

# Acknowledgements

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- Berthold Hahn, Co-operating agent

- Organizing Committee:

Mike Purdue, Des Farren, Vijayant Kumar, Alex Clerc, Alex Koltisdopolous, Nikolay Dimitrov, Jan Helsen, Lindy Williams, Shawn Sheng

- Technical Contributors:

Joseph Lee, Steve Clark, John Meissner, Andrew Bray, Heather Doane



# Agenda

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What is Digitalization? Why do we care?



IEA and Task 43 Background



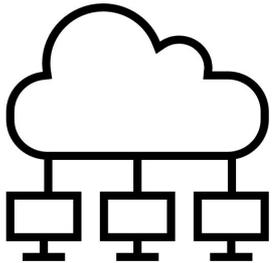
Approach & supporting agenda

# Digital Technology: what is it? why now?

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compute



Large and  
small  
Distributed  
Cloud  
Edge

connectivity



Internet  
Mobile  
5G

sensors &  
data

000111  
100110  
111011

Proliferation of  
data  
Decreasing cost  
of sensors  
IoT

software

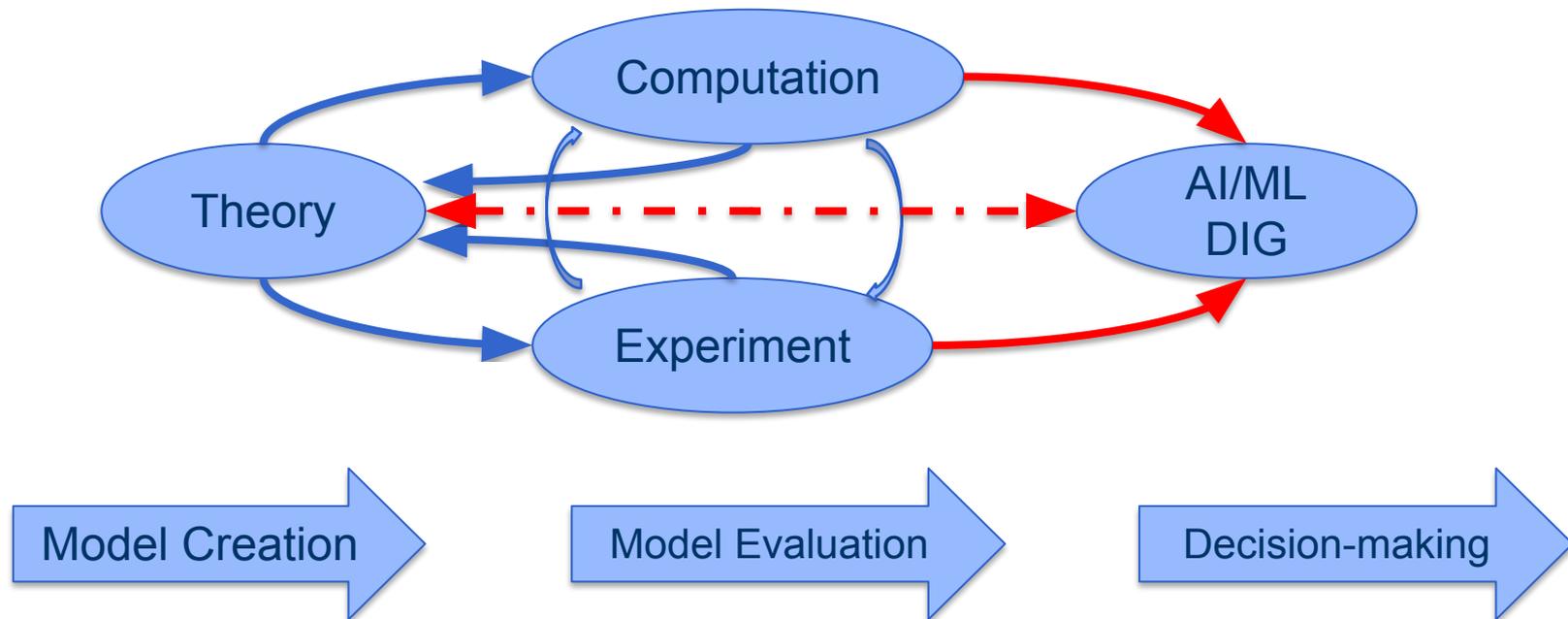
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AI/Machine  
learning  
Blockchain  
Big data  
Open Source

# Artificial Intelligence



AI/ML/Digitalization are emerging as a 4<sup>th</sup> pillar of scientific inquiry



# Artificial Intelligence

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AI is disruptive.

It won't replace the scientist, but scientists who use AI will replace those who don't.

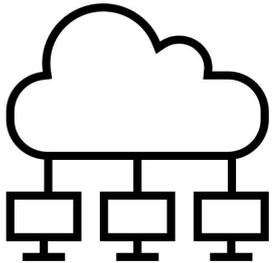
-- *Microsoft Report: The Future Computed, 2018*

# Digital Technology: what is it? why now?

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compute



Large and small  
Distributed  
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connectivity



Internet  
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sensors & data

000111  
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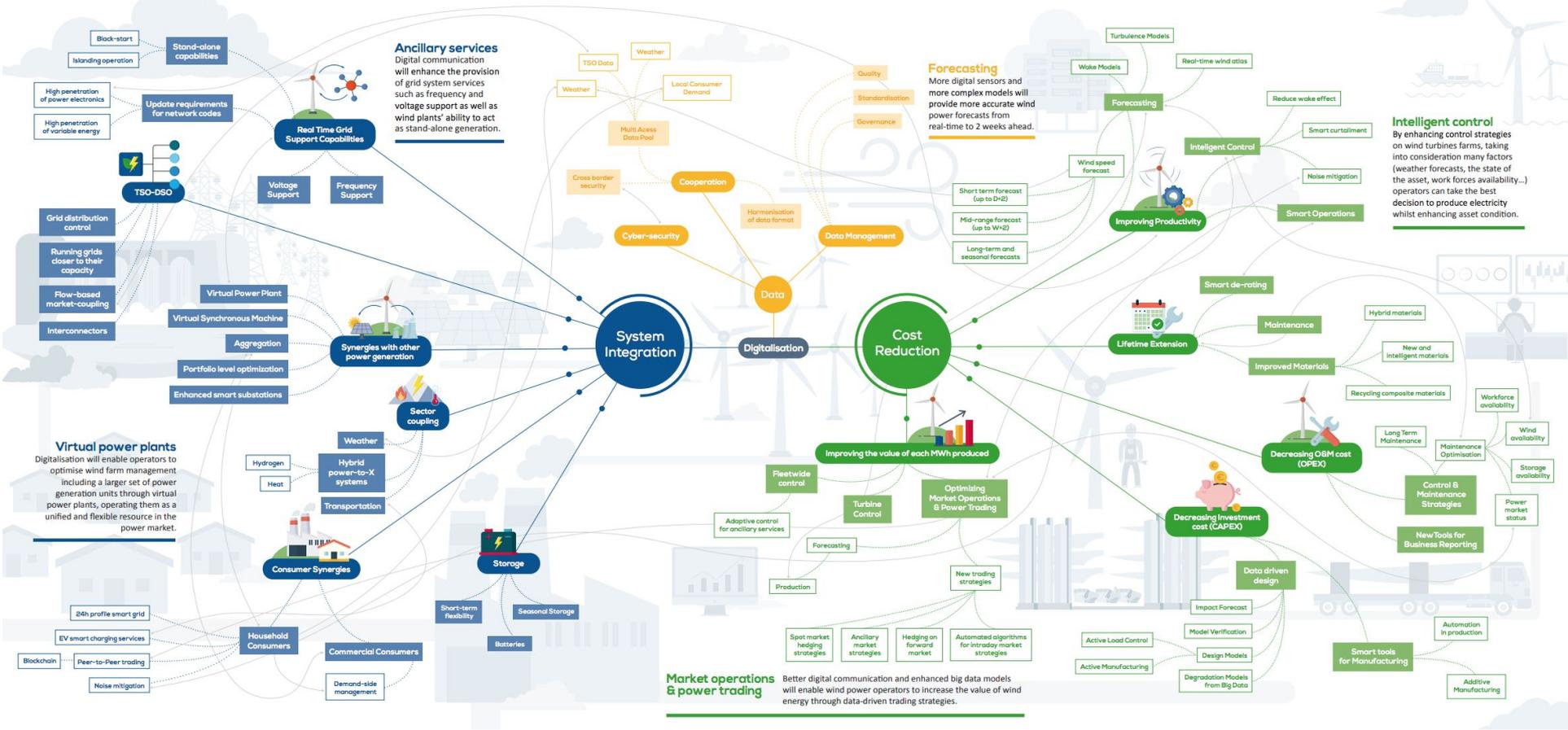
Proliferation of data  
Decreasing cost of sensors  
IoT

software

< / >  
{...}  
{js}

AI/Machine learning  
Blockchain  
Big data  
Open Source

# Wind Energy Digitalization: wild eyed possibilities



# Wind Energy Digitalization: why do I care?

DeepMind AI Reduces Google Data Centre Cooling Bill by 40%

**Under Armour: grew revenue \$80 million for fitness connected devices with AI fitness app**

**35% of Amazon.com's revenue is generated by its recommendation engine.**

1. <https://deepmind.com/blog/deepmind-ai-reduces-google-data-centre-cooling-bill-40/>
2. <https://www.mckinsey.com/industries/retail/our-insights/how-retailers-can-keep-up-with-consumers>
3. <https://emerj.com/ai-sector-overviews/5-business-intelligence-analytics-case-studies-across-industry/>

# Wind Energy Digitalization: be skeptical!



ILLUSTRATION BY DAVID PARKINS



## Retire s

Valentin Amrhein, Sander Greenland, Blake McShane and more than 800 signatories call for an end to hyped claims and the dismissal of possibly crucial effects.

### Automated Inference on Criminality using Face Images



(a) -0.98

(b) -0.68

(c) -0.28

(d) -0.38



(e) 0.76

(f) 0.98

(g) 0.66

Figure 5. Purported subtypes of criminal (top) and non-criminal (bottom) faces. From Wu and Zhang (2016).

Journal of  
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SOUNDCLOUD  
Download Share



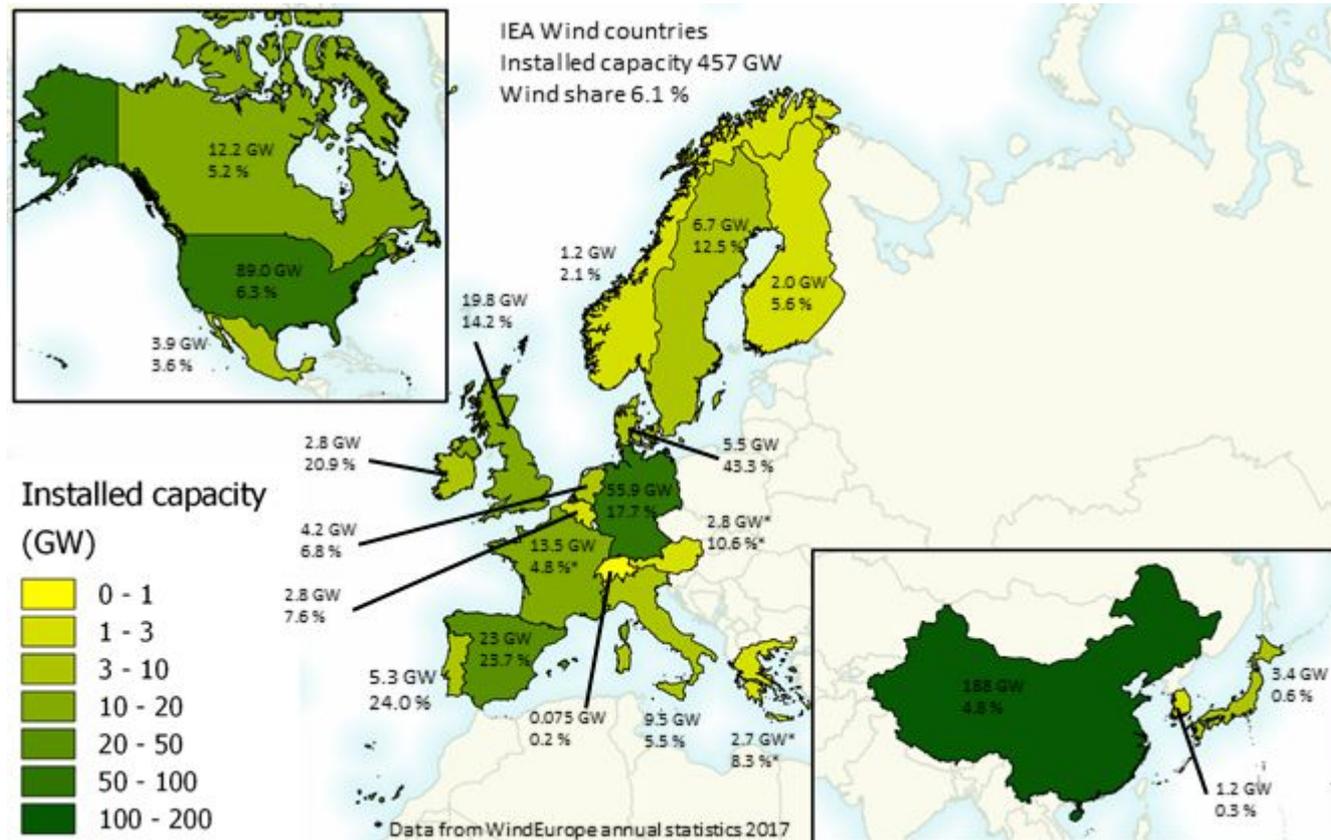
# International Energy Agency

*Founded:1974*

*Mission: Facilitate energy security and energy policy co-operation*

*IEA Wind:*

*21 countries represent 85% of global installed capacity*



# IEA Wind Accomplishments

EXPERT GROUP RECOMMENDED P...

17. WIND FARM DATA COLLECTI...  
ASSESSMENT FOR O&M

FIRST EDITION

**re·li·a·bil·i·ty**  
a person or thing with trustworthy qualities.

Edited by:  
Berthold Hahn  
Fraunhofer Institute for Wind Energy and Er...  
Koenigstor 59, D-341...  
Germany

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- Gerard van Bussel, Delft University of Technol
- Jørn Vatn, NTNU Norwegian University of Science and Technology, Norway
- Thomas Welte, SINTEF Energy Research, Norway

AAAS [Become a Member](#)

## Science

Contents ▾ News ▾ Careers ▾ Journals ▾

**SHARE** REVIEW

### Grand challenges in the science of wind energy

Paul Veers<sup>1,\*</sup>, Katherine Dykes<sup>2,\*</sup>, Eric Lantz<sup>1,\*</sup>, Stephan Barth<sup>3</sup>, Carlo L. Bottasso<sup>4</sup>, Ola Carlson<sup>5</sup>, Andrew Clifton<sup>6</sup>, Johnney G...  
+ See all authors and affiliations

*Science* 25 Oct 2019:  
Vol. 366, Issue 6464, eaau2027  
DOI: 10.1126/science.aau2027

**Article**   [Figures & Data](#)   [Info & Metrics](#)   [eLetters](#)    PDF

**A multifaceted future for wind power**

Modern wind turbines already represent a tightly optimized confluence of materials science and aerodynamic engineering. Veers *et al.* review the challenges and opportunities for further expanding this technology, with an emphasis on the need for interdisciplinary collaboration. They highlight the need to better understand atmospheric physics in the regions where taller turbines will operate as well as the materials constraints associated with the scale-up. The mutual interaction of turbine sites with one another and with the evolving features of the overall electricity grid will furthermore necessitate a systems approach to future development.

*Science*, this issue p. [eaau2027](#)



# IEA TEM 92: Wind Energy Digitalization

## By the numbers

- 50 participants from 36 companies and 12 countries
  - *One of the largest wind TEMs to date*
- 2 days, 15 presentations, breakout sessions



# ***IEA TEM 92: Key Points***

- Definition of **wind digitalization broad and ill defined**
- Value proposition seems large/disruptive but unquantified
- Advanced technology like **machine learning and big data held back** by lack of standardized datasets
- **Standards critically important** but under adopted and ill defined patchwork
- **60-80%** of current data analysis effort is data wrangling
- **Open Source tools** drive community engagement, data sharing and data standards

# IEA TEM 92:

## Proceedings and Presentations

- IEA TEM 92 Proceedings

[http://bit.ly/IEA\\_TEM\\_92\\_proceedings](http://bit.ly/IEA_TEM_92_proceedings)

- IEA TEM 92 Presentations

[http://bit.ly/IEA\\_TEM\\_92\\_presentations](http://bit.ly/IEA_TEM_92_presentations)



INTERNATIONAL ENERGY AGENCY  
Implementing Agreement for Co-operation in the Research,  
Development and Deployment of Wind Turbine Systems  
Task 11

Topical Expert Meeting #92 on

### Wind Energy and Digitalization

IEA Wind Task 11- Topical expert meeting

October 4-5, 2018

Sustainable Energy Authority of Ireland, Dublin, Ireland



PLANAIR

Hosts:  
John McCann, Sustainable Energy Authority of Ireland SEAI

Technical lead:  
Jason Field, National Renewable Energy Laboratory NREL  
Des Egan, ~~Sonoma~~ Informatics  
Berthold Hahn, Fraunhofer IEE

Operating agent:  
Nadine Mounir, ~~Enovos~~ SA

# IEA Wind Energy Digitalization: Outreach and engagement



- WindEurope Poster(J. Fields)
- In person meeting: April 1, 2019-Bilbao
- Online survey
- AWEA WRA Poster(M. Purdue)
  
- Kickoff Meeting: Nov 5-7, 2019 Boulder, CO

PO.004

**International Energy Agency (IEA)**  
**Topical Experts Meeting #92:**  
**Wind Energy Digitalization**

Jason Fields<sup>1</sup> Des Farren<sup>2</sup> Berthold Hahn<sup>3</sup> John McCann<sup>4</sup> Nadine Mounir<sup>5</sup>  
<sup>1</sup>NREL <sup>2</sup>ServusNET <sup>3</sup>Fraunhofer <sup>4</sup>SEAI <sup>5</sup>Plenair

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**Abstract**

Digitalization is the use of digital technologies to change a business model and provide new revenue and value-producing opportunities; it is the process of moving to a digital business!

The International Energy Agency sponsored a topical experts meeting (TEM) with 46 experts from 11 countries who presented their work on wind energy digitalization. This poster reviews the meeting results and the 18 different presentations on the state of the art for wind energy digitalization.

**Digitalization Technologies<sup>2</sup>**

<p>computers</p> <p>Large and small Distributed Cloud Edge</p>	<p>connectivity</p> <p>Internet of Things Mobile 5G</p>	<p>sensors &amp; data</p> <p>000111 100110 111011</p> <p>Proliferation of data Decreasing cost of sensors IoT</p>	<p>software</p> <p>&lt;/&gt; (.) {}</p> <p>Machine learning Blockchain Big data AI</p>
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**Digitalization Market Impacts<sup>3</sup>**

**Objectives for digitalization**

<p><b>System integration</b>  <small>Maximizing the full potential of wind energy</small>                      Requires increased energy grid distribution penetration and the key aspects of the future energy system. New data-based models, increased connectivity and increased renewable wind farms and the other assets are needed. Cross-sectoral examples will facilitate the integration of wind in the electricity system.</p> <p><b>TSO-DSO</b>                      More and higher quality data exchange between system operators and wind power generation will optimize the management and distribution of their energy throughout the grid.</p> <p><b>Real-time grid support capabilities</b>                      Distributed generation will provide new means to provide more grid services faster and more efficiently.</p> <p><b> synergies with other power generation</b>                      Higher penetration of wind power plants with other power generation, facilitating system heat energy management.</p> <p><b>Consumer synergies</b>                      Distributed and flexible management will improve operational performance and interacting with power generation.</p> <p><b>Tethered floating</b>                      Distributed and flexible management offers opportunities to integrate distributed generation between the electricity sector and other energy carriers.</p> <p><b>Storage</b>                      Integrating coupling wind power and storage will enhance wind energy to become a crucial part of the energy system.</p>	<p><b>Reducing Data Production</b>  <small>Producing clean and affordable clean energy</small>                      Wind energy has the potential to contribute to the grid and the other assets are needed, as well as using the data to improve the wind power production.</p> <p><b>Increasing productivity</b>                      Increased forecasting and control center load forecasting will enable better to increase the wind power production.</p> <p><b>Increasing O&amp;M cost (O&amp;M)</b>                      Increased forecasting based on new data-based models will reduce the O&amp;M cost and increase the wind power production.</p> <p><b>Increasing investment cost (CAPEX)</b>                      Increased forecasting and control center load forecasting will enable better to increase the wind power production.</p> <p><b>Private information</b>                      Information that is not shared between the wind power generation and the other assets are needed, as well as using the data to improve the wind power production.</p> <p><b>Reducing the value of each kWh produced</b>                      Increased forecasting and control center load forecasting will enable better to increase the wind power production.</p>
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**IEA TEM 92 Key Themes**

Digitalization: Opportunities to Add Value Throughout the Lifecycle

- Definition of wind digitalization broad and ill defined
- Value proposition large and disruptive but unquantified
- Advanced technology like machine learning and big data held back by lack of standardized datasets
- Standards critically important but under adopted and ill defined patchwork
- 60-80% of current data analysis effort is data wrangling
- Open Source tools drive community engagement, data sharing and data standards

**Conclusions & Next Steps**

- IEA TEM 92 Presentations available on [IEA Wind Platform](#)
- IEA TEM 92 Proceedings available on [IEA Wind Platform](#)
- New IEA Collaborative Task Proposal in Draft now with major focus areas:
  - White paper/Journal Article on Wind Energy Digitalization Opportunity
  - Opportunity
  - Wind Energy Digitalization roadmap
  - Focused topical area research including
    - Gap analysis and adoption of data standards
    - Digital Operations & Maintenance (O&M)
    - Digital Wind Resource Assessment (WRA)

**Currently seeking volunteers willing to contribute to any of the themes, work packages or technologies above.**  
[Email: wind.digitalization@nrel.gov](mailto:wind.digitalization@nrel.gov)

**References**

1. <https://www.windenergy.com/news/2018/07/10/iea-tem-92>
2. Wilkinson, M. (2018), Wind Energy Digitalization DNV-GL.
3. <https://www.nrel.gov/wind/iea-tem-92/wind-energy-digitalization.html>
4. <https://www.nrel.gov/wind/iea-tem-92/wind-energy-digitalization.html>
5. <https://www.nrel.gov/wind/iea-tem-92/wind-energy-digitalization.html>

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**Access the IEA TEM 92 resources here:**  
[http://bit.ly/IEA\\_TEM\\_92\\_proceedings](http://bit.ly/IEA_TEM_92_proceedings)  
[http://bit.ly/IEA\\_TEM\\_92\\_presentations](http://bit.ly/IEA_TEM_92_presentations)

[windenergy.com/conf2019](http://windenergy.com/conf2019)  
 #WindEurope2019

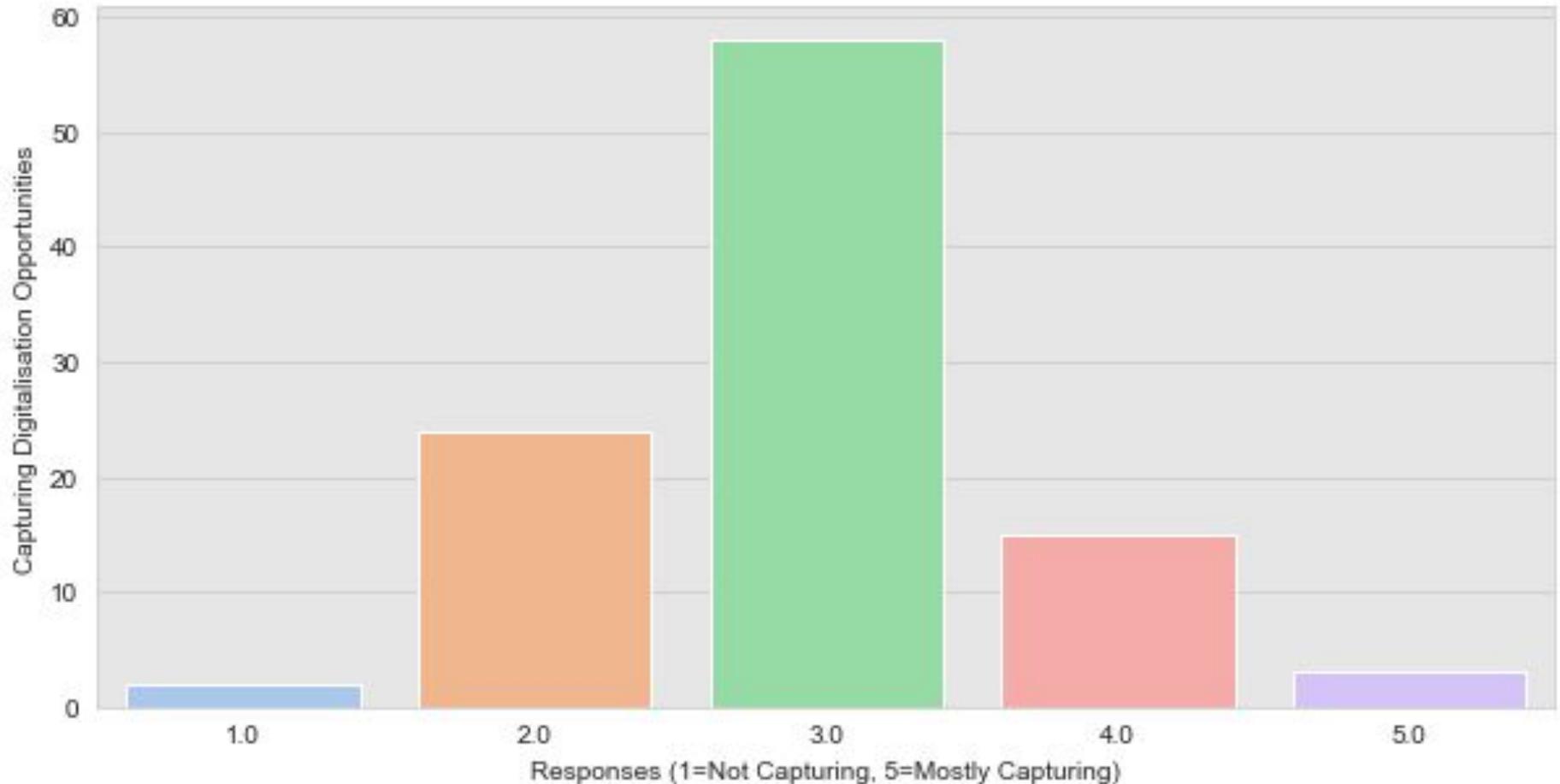
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**Wind EUROPE CONFERENCE & EXHIBITION 2019**

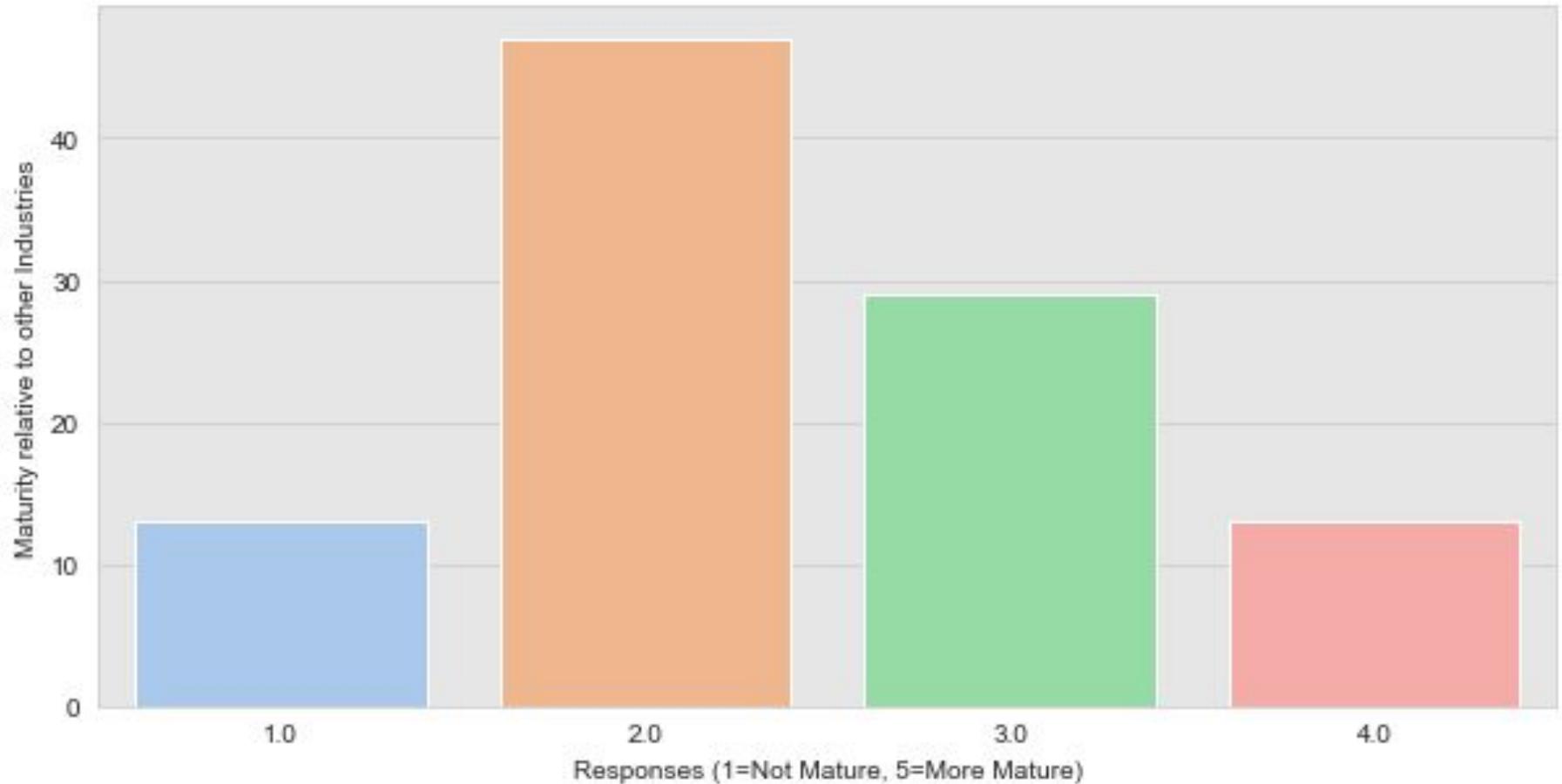
Download the poster

# Are we capturing digitalization opportunities?

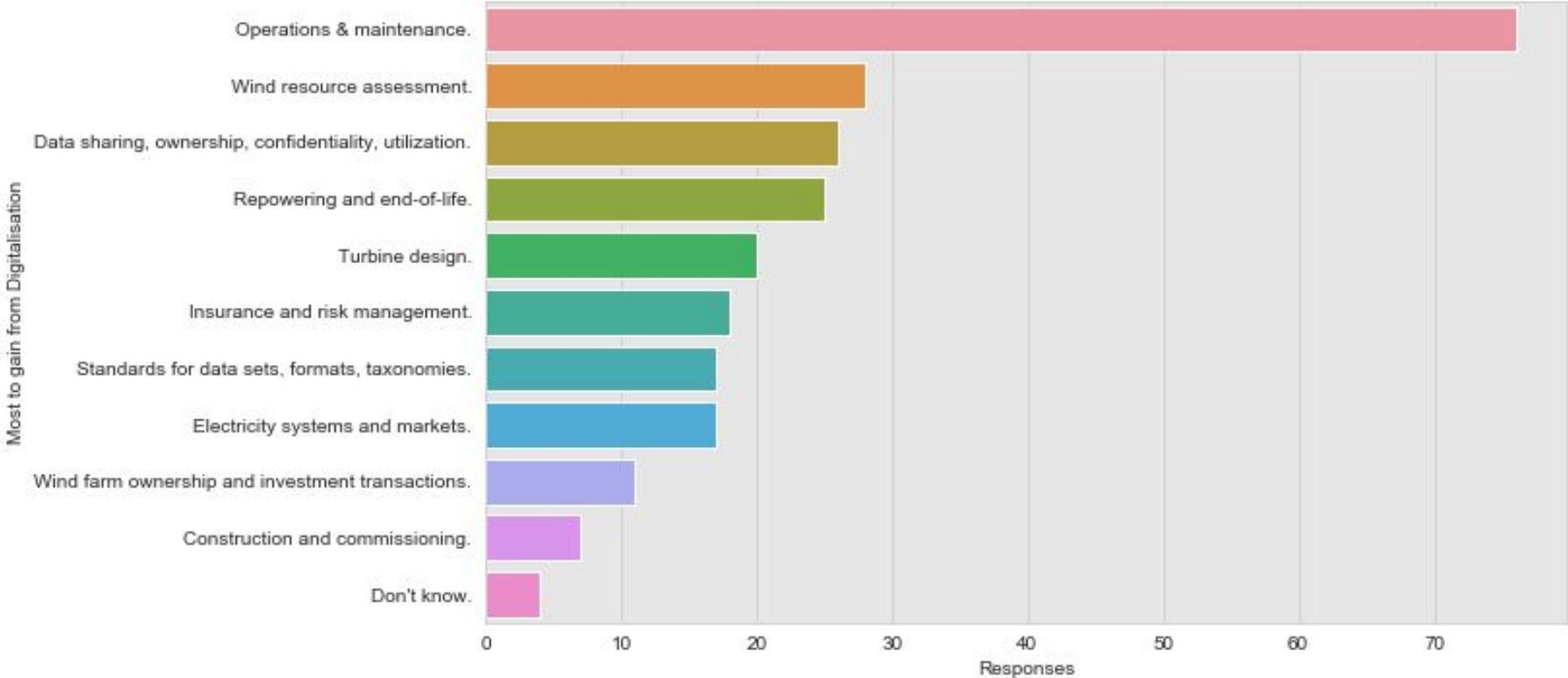
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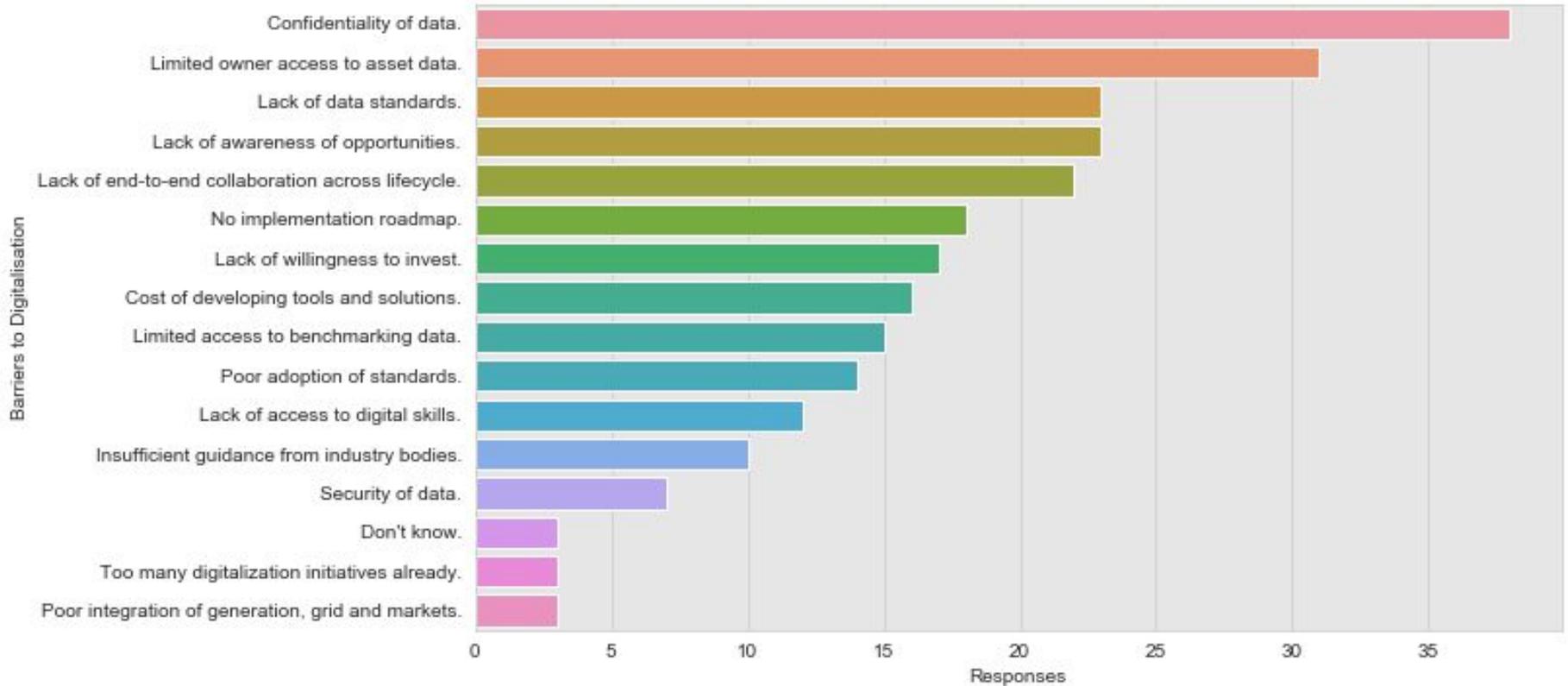
# Wind industry relative maturity in digitalization



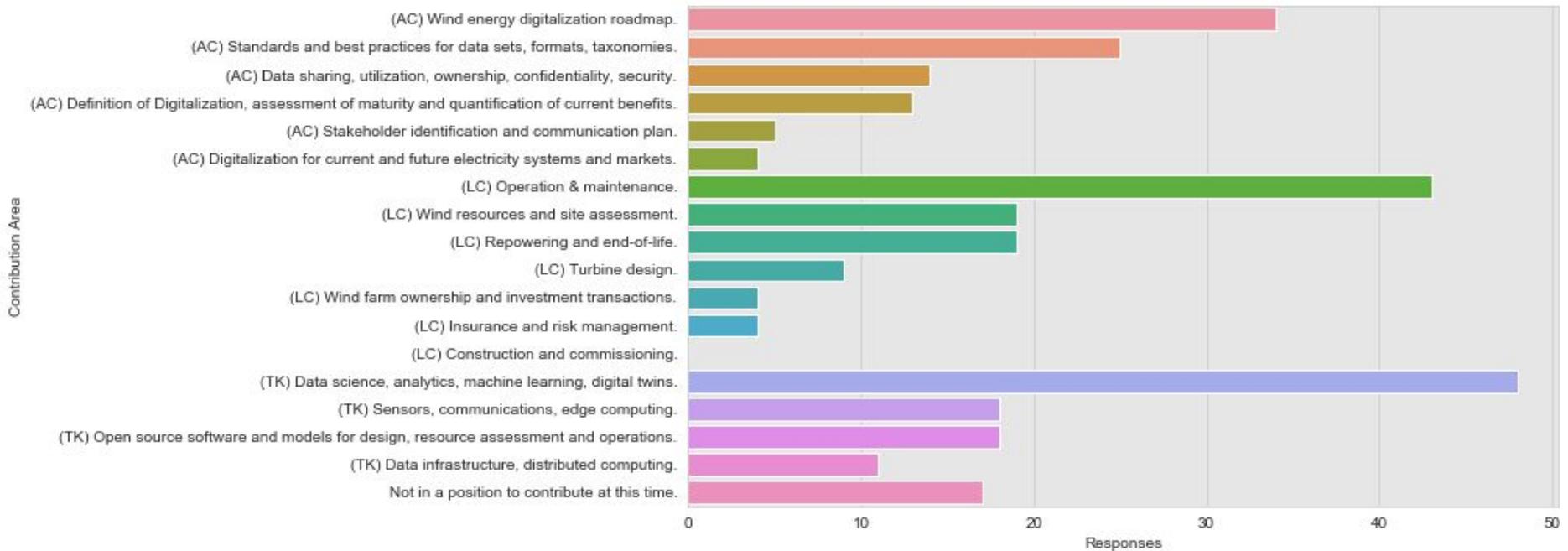
# Digitalization opportunities



# Barriers to Digitalization



# Stakeholder Interest



# IEA 43: Work Packages

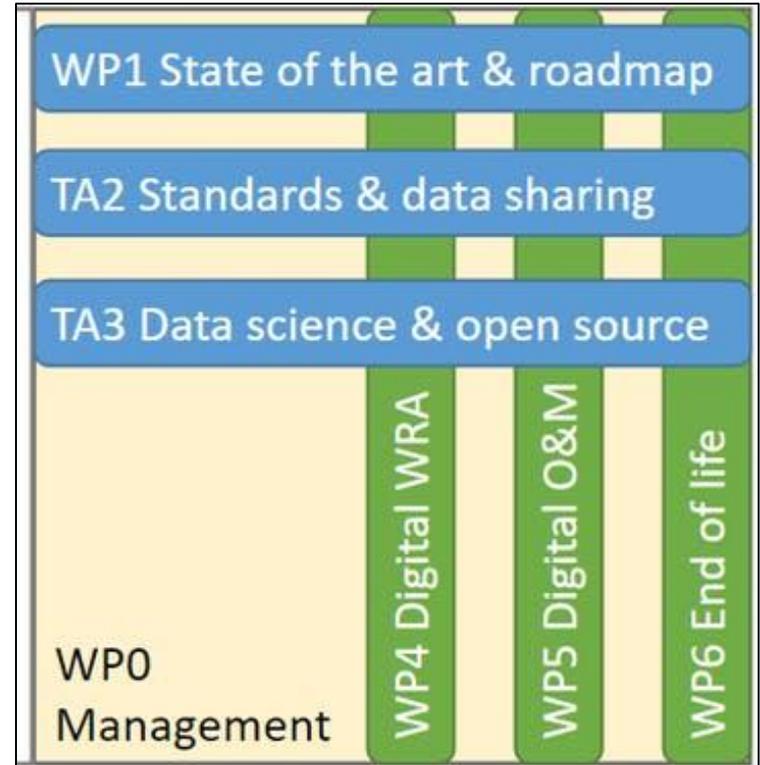


WP1-3: Cross cutting

WP4-6: Application areas

Deliverables:

- Data Standards, Best Practices, and open source tools



Early Participants: DNV-GL, EDF R&D, EDF Energy, NREL, NRG Systems, Fraunhofer IEE, DTU, RES, Sentient Science, GI-Engineering, OWI-lab/VUB, GE, Siemens-Gamesa

# Meeting Goals & Outcomes

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- Update stakeholders on current status of IEA Task 43
- Finalize Task 43 work packages
  - Scope
  - Leaders & Contributors
- Start the work & Define next steps
- Create community and collaboration on wind energy digitalization

# Approach

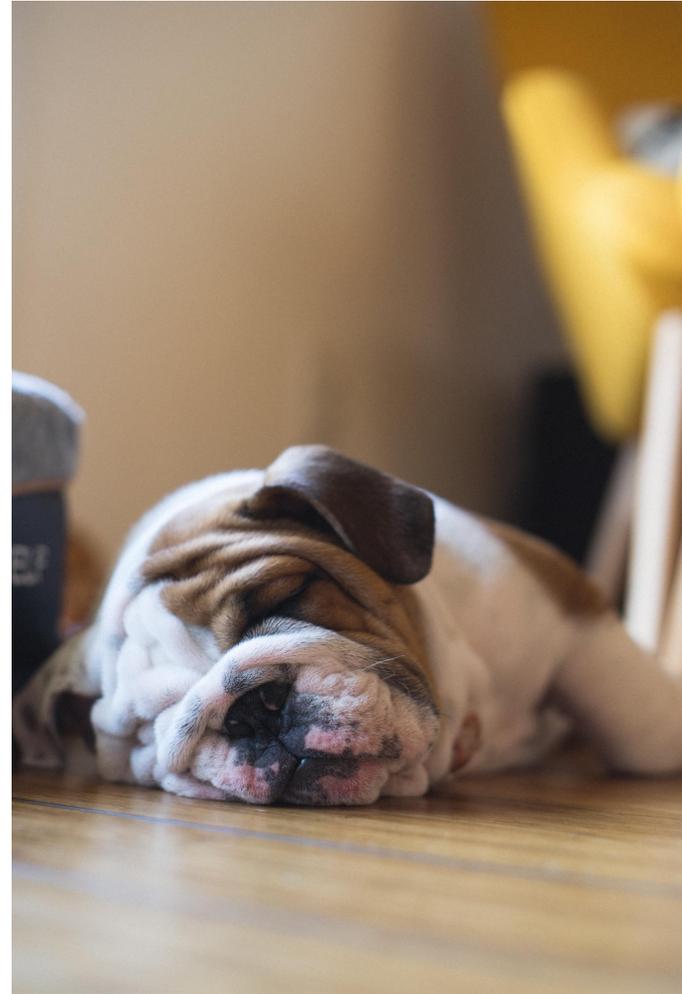
Some of this . . .



A lot of this . . .



To avoid this. . .



# Agenda Day 1

<b>Tue 5th Nov</b>	8:15 AM	<i>Breakfast</i>	
	8:30 AM	Welcome Plenary Session ( <i>Purpose, Goals, Agenda Overview, Introductions</i> )	
	9:00 AM	Task Updates ( <i>Work Package Overview, How We Got Here, Goals- 10min per WP or TA</i> )	
	10:10 AM	Q&A and Clarifications	
	10:20 AM	<i>Break</i>	
	10:30 AM	Parallel Working Sessions, Organization	<ul style="list-style-type: none"> <li>● WP1 State-of-the-art and Roadmap</li> <li>● WP4 Wind Resource Assessment</li> <li>● WP5 Operations and Maintenance</li> <li>● WP6 End of Life and Repowering</li> </ul>
	12:00 PM	<i>Lunch and networking</i>	
	1:00 PM	Keynote: Artificial Intelligence: State of the Art ( <i>Vijayant Kumar</i> )	
	1:30 PM	Parallel Working Sessions, Work to Date	<ul style="list-style-type: none"> <li>● WP1 State-of-the-art and Roadmap</li> <li>● WP4 Wind Resource Analysis</li> <li>● WP5 Operations and Maintenance</li> <li>● WP6 End of Life and Repowering</li> </ul>
	4:15 PM	Plenary Report Out ( <i>Progress, Questions, Issues, Help Needed</i> )	
	5:00 PM	<i>Plenum Departs, Organizing Committee Prepares for Day 2</i>	
7:00 PM	<i>No Host Group Dinner: Mediterranean Restaurant</i>		

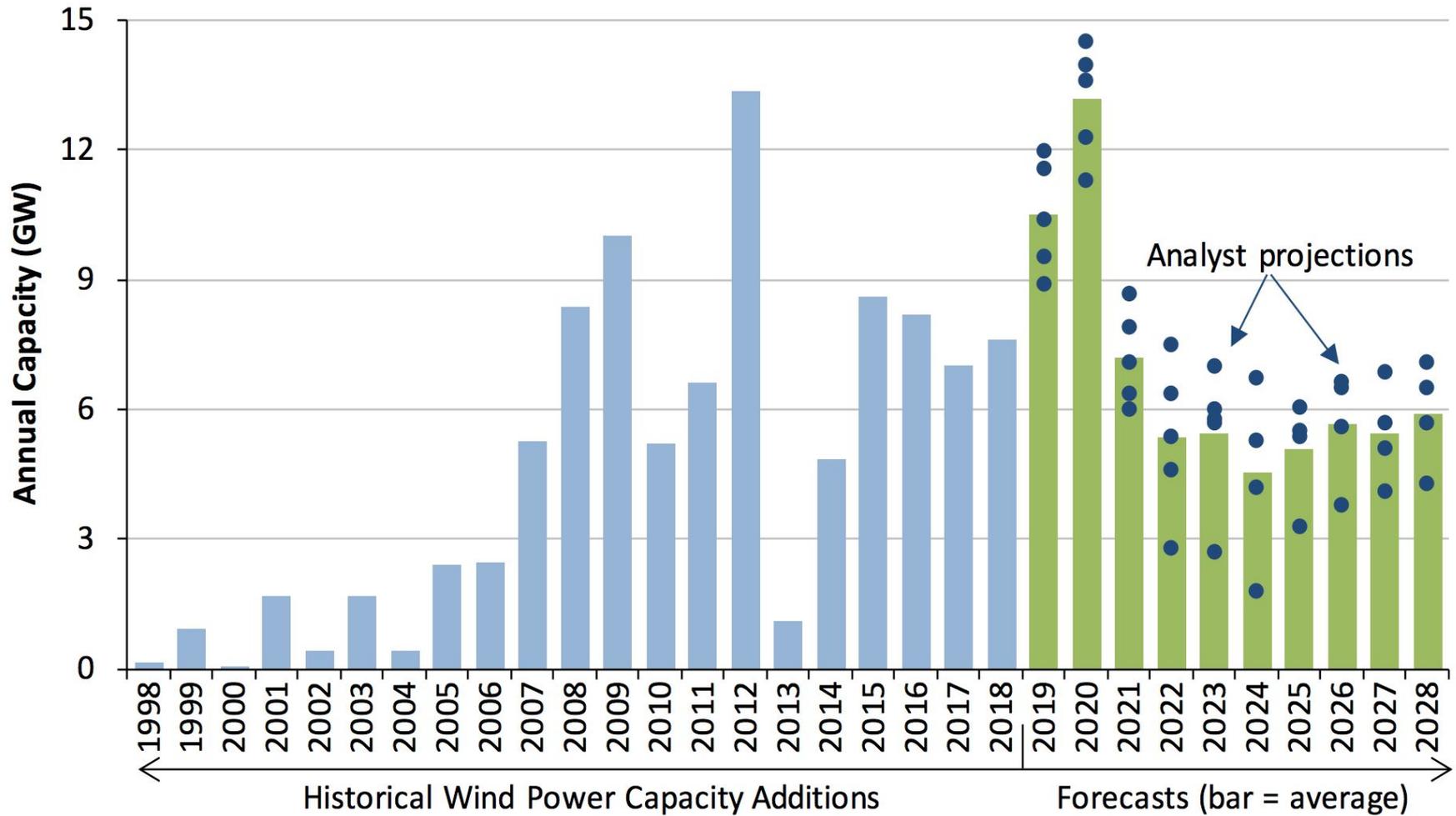
# Agenda Day 2

Wed 6th Nov	8:15 AM	<i>Breakfast</i>	
	8:30 AM	Plenary Session – Address Questions and Issues from Day 1	
	9:00 AM	Keynote: Artificial Intelligence: Investing in the Future ( <i>David Womble</i> )	
	9:30 AM	Parallel Working Sessions, Deliverables	<ul style="list-style-type: none"> <li>● WP1 State-of-the-art and Roadmap</li> <li>● WP4 Wind Resource Analysis</li> <li>● WP5 Operations and Maintenance</li> <li>● WP6 End of Life and Repowering</li> </ul>
	12:00 PM	<i>Lunch and networking</i>	
	1:00 PM	Keynote: Data Standards: Successes from other industries & how they did it ( <i>Charles Henderson</i> )	
	1:30 PM	Parallel Working Sessions, Work Toward Deliverables	<ul style="list-style-type: none"> <li>● WP1 State-of-the-art and Roadmap</li> <li>● WP4 Wind Resource Analysis</li> <li>● WP5 Operations and Maintenance</li> <li>● WP6 End of Life and Repowering</li> </ul>
	4:15 PM	Plenary Report Out ( <i>Progress, Questions, Issues, Help Needed</i> )	
	5:00 PM	<i>Plenum Departs, Organizing Committee Prepares for Day 3</i>	
7:00 PM	<i>No Host Group Outing: Rayback Collective</i>		

# Agenda Day 3

Thur 7th Nov	8:00 AM	<i>Breakfast</i>	
	8:15 AM	Plenary Session – Address Questions and Issues from Day 2	
	8:45 AM	Data standards & sharing plenary discussion (TA2)	
	9:30 AM	Data science & open source plenary discussion (TA3)	
	10:15 AM	Parallel Working Sessions; Ensure Work Continues	<ul style="list-style-type: none"><li>● WP1 State-of-the-art and Roadmap</li><li>● WP4 Wind Resource Analysis</li><li>● WP5 Operations and Maintenance</li><li>● WP6 End of Life and Repowering</li></ul>
	12:45 PM	<i>Lunch and networking</i>	
	1:30 PM	Plenary Report Out ( <i>Next Steps, Questions, Issues, Help Needed</i> )	
	2:45 PM	“Thank You!” and Looking Forward	
	3:00 PM	<i>Plenum Departs, Organizing Committee Wrap Up</i>	

# Market predictions



Source: LBNL Market Report

# Staying Below 2 degrees



It is widely believed that we are approaching a tipping point for carbon emissions.

2

TWO DEGREES

CELSIUS COULD DECIDE OUR FATE

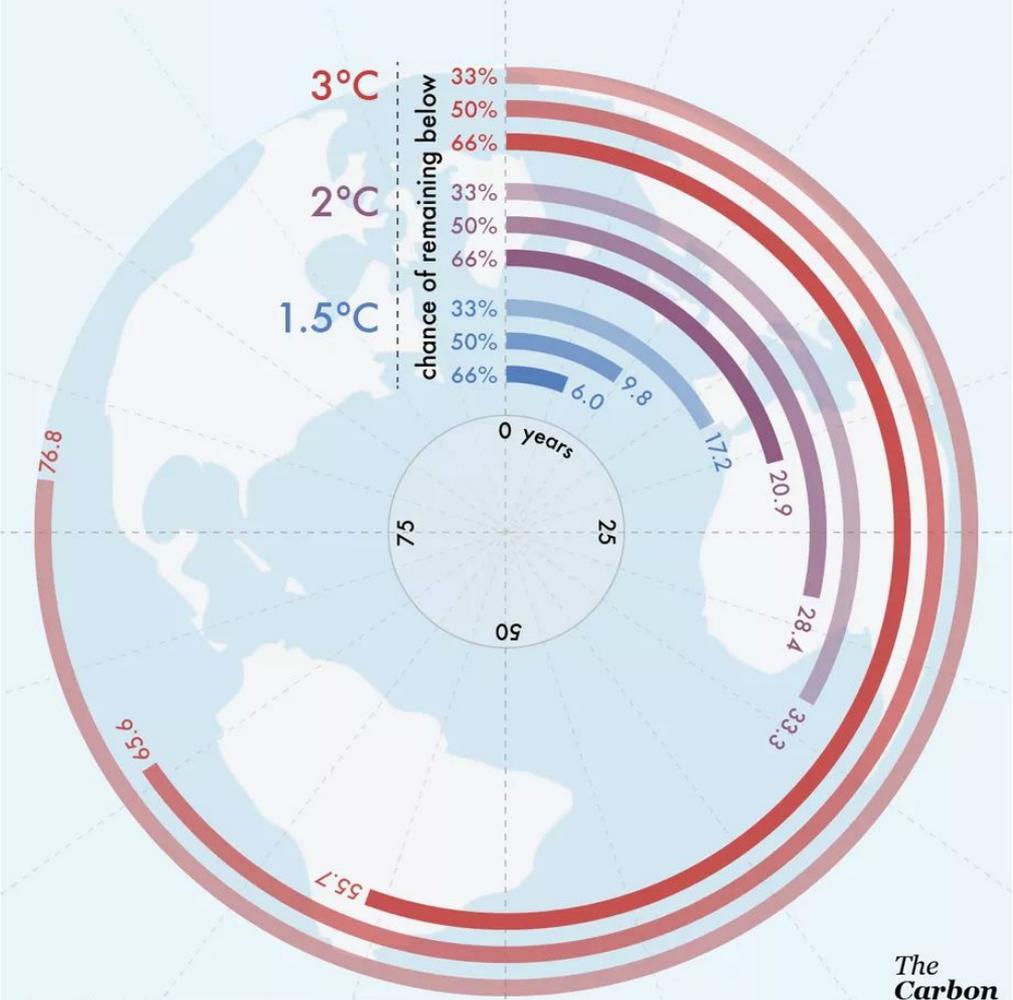
Source:

<http://www.cbc.ca/radio/thecurrent/a-special-edition-of-the-current-for-november-30-2-degrees-1.3343179/paris-climate-smithsonian-2-degrees-could-decide-our-fate-1.3348125>

# Staying Below 2 degrees

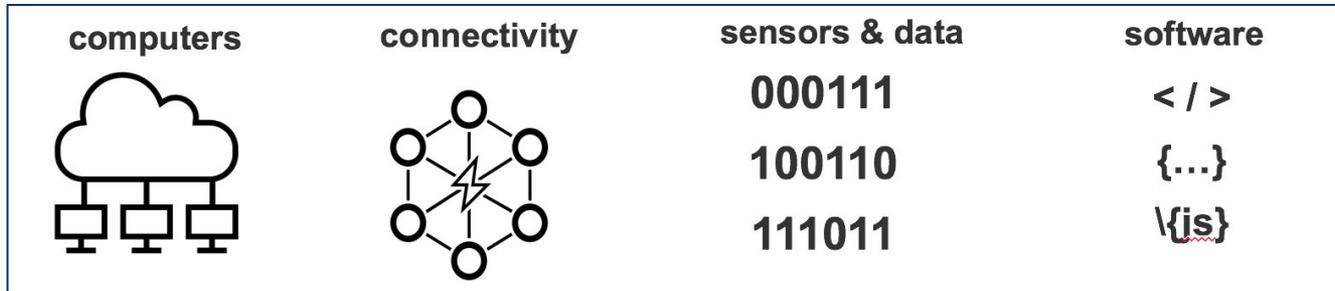
## Carbon Countdown

How many years of current emissions would use up the IPCC's carbon budgets for different levels of warming?

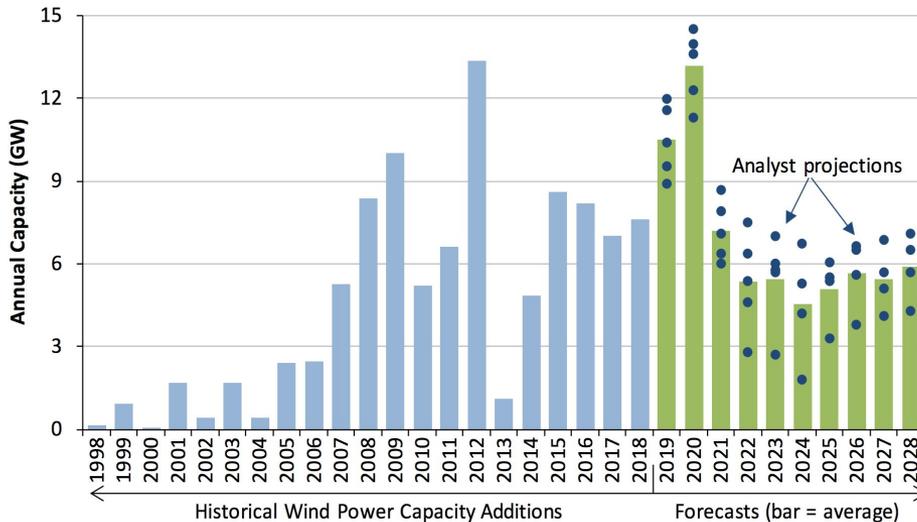


# Value of Digitalization

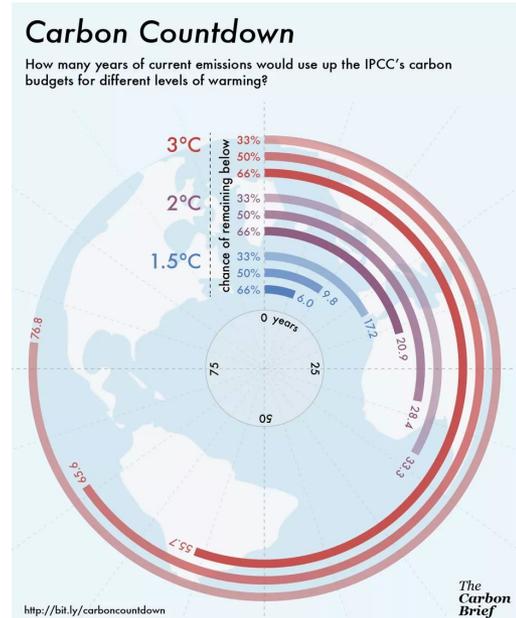
How does this?



Help this?



And this?

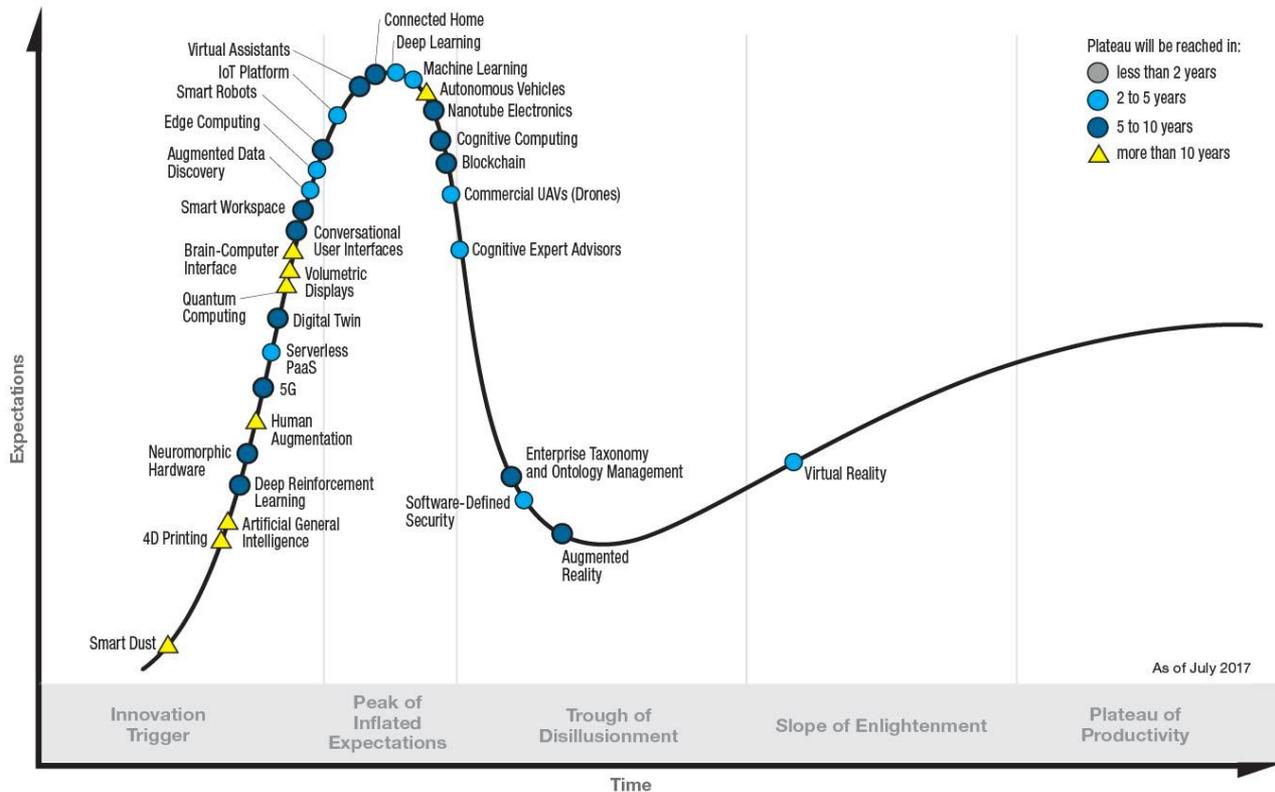


# Wind Energy Digitalization- be

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## Gartner Hype Cycle for Emerging Technologies, 2017



[gartner.com/SmarterWithGartner](http://gartner.com/SmarterWithGartner)

Source: Gartner (July 2017)  
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Gartner



red wind

# Appendix

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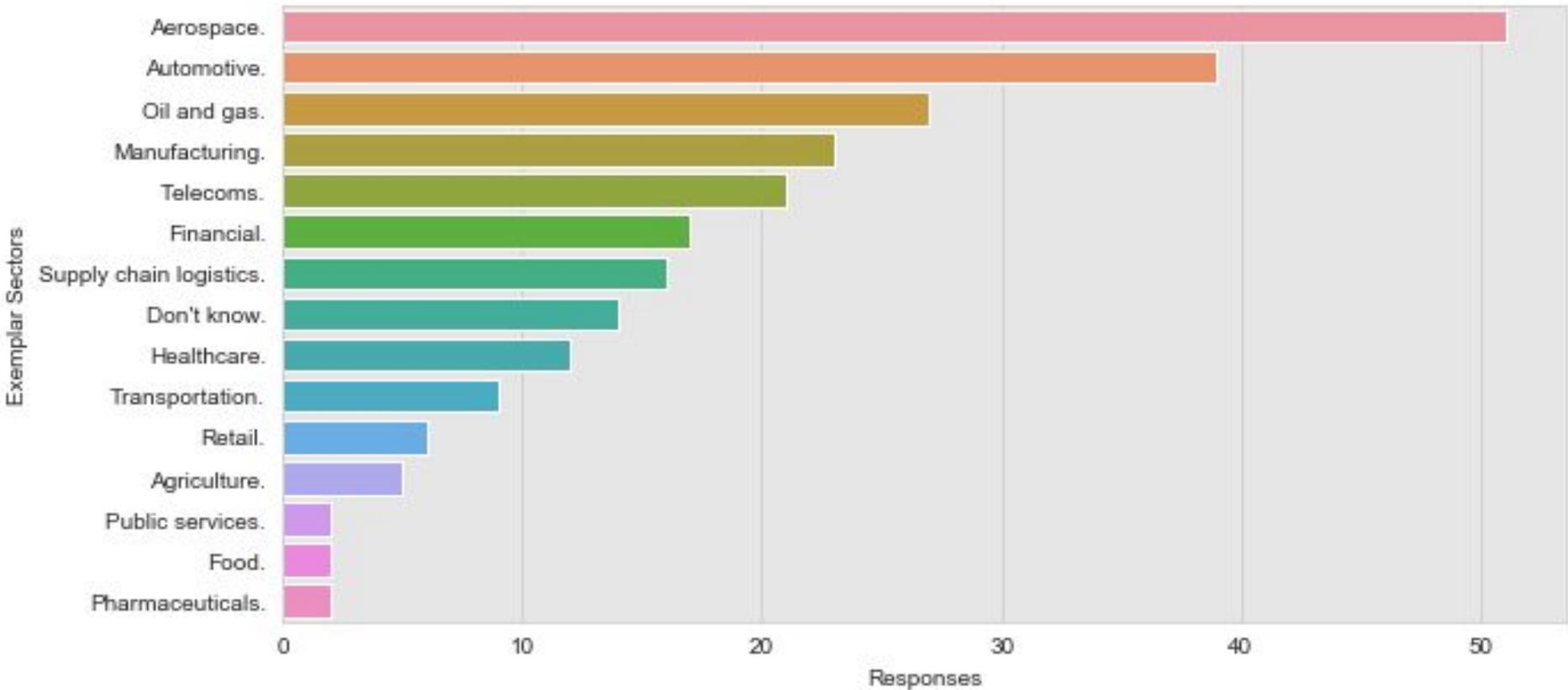
# Operations

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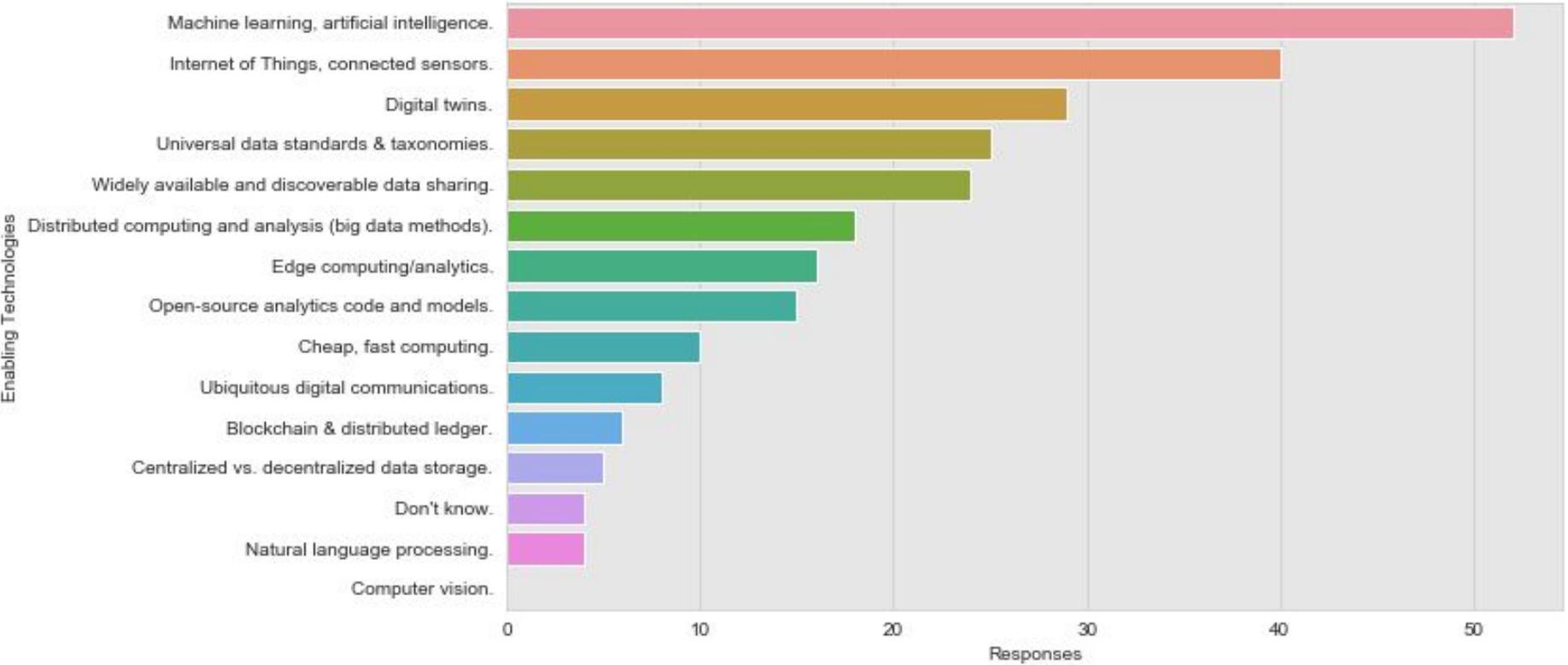


- Operating Agents:
  - Jason Fields, NREL (US)
  - Berthold Hahn, Fraunhofer (DE)
- Expected budget: ~95,000 € annually
- Annual Cost:
  - 12 countries: €8000
  - 16 countries: €6000
- Joint work packages:  
IEA Tasks, IEC TC88, ESIG, AWEA, WindEurope, RDA,  
AI for Science

# Other Digital industries



# Enabling Technologies



# Definitions

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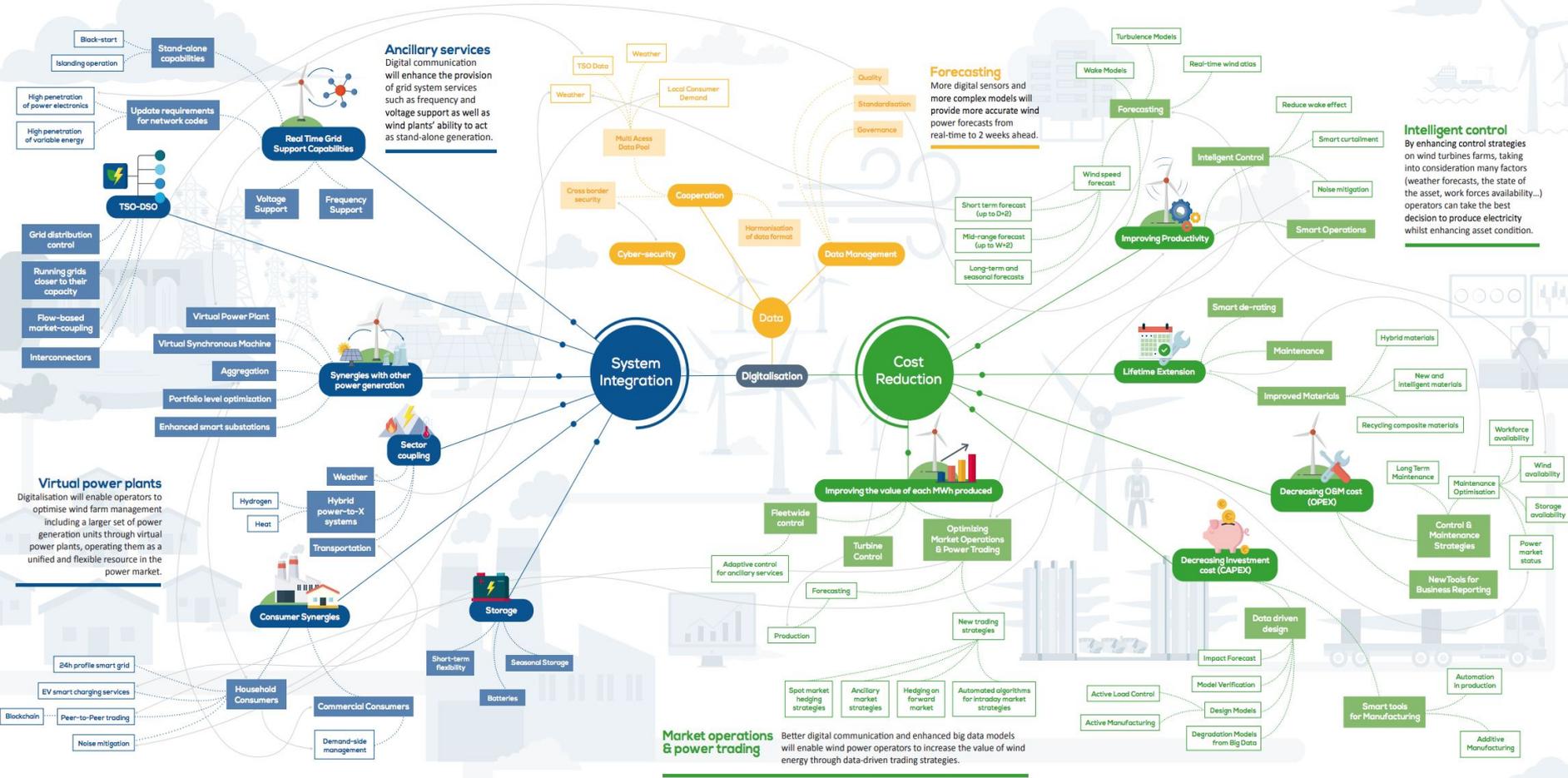
What do we mean by artificial intelligence, machine learning, and Big Data?

***Artificial Intelligence (AI)** is the science and engineering of making intelligent machines... intelligence is the computational part of the ability to achieve goals – John McCarthy*

***Machine Learning (ML)** is a type of AI that gives computers the ability to learn from data without being explicitly programmed – Arthur Samuel*

**Digitalization** refers to creating and curating large datasets that creates an ecosystem where AI/ML can learn predictive abilities

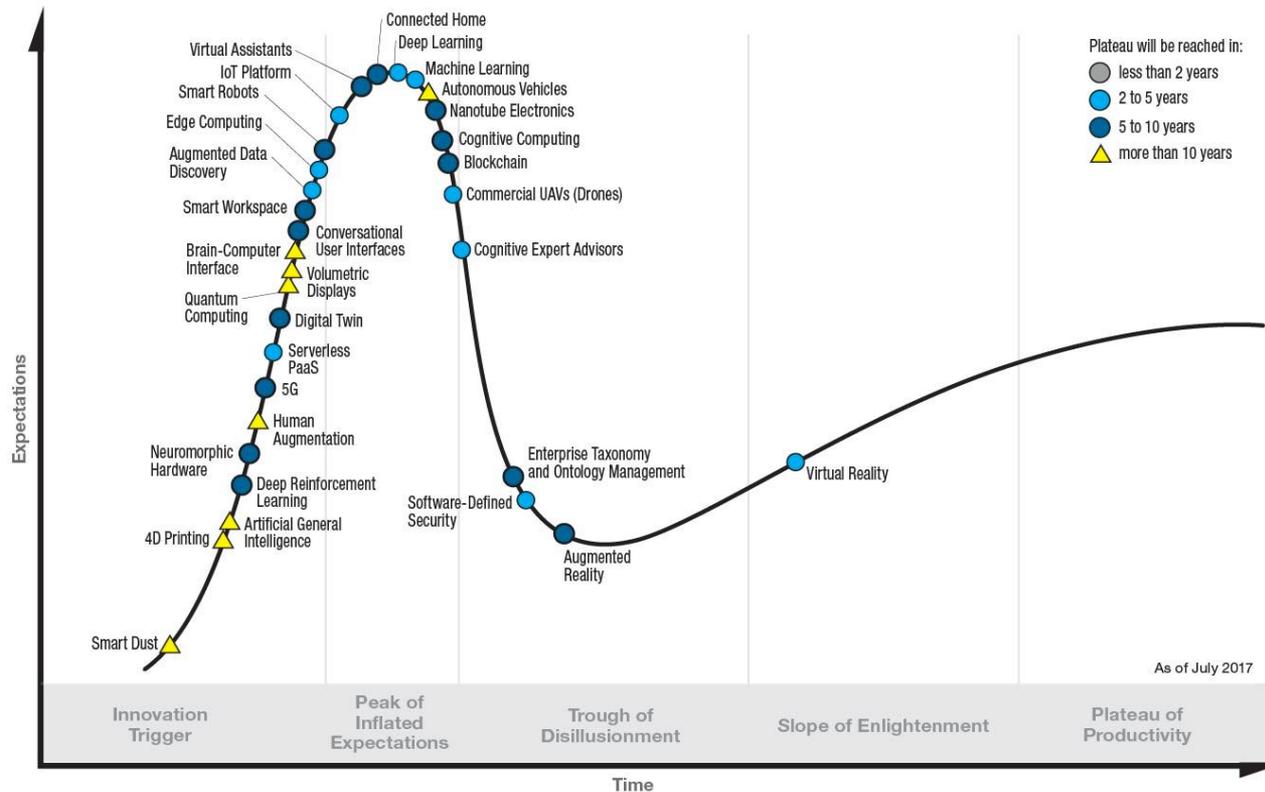
# Wind Energy Digitalization: wild eyed possibilities



# Wind Energy Digitalization- be skeptical!



## Gartner Hype Cycle for Emerging Technologies, 2017



[gartner.com/SmarterWithGartner](http://gartner.com/SmarterWithGartner)

Source: Gartner (July 2017)  
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**Gartner**

# Example applications of digital technology in the wind industry



## Blockchain

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Example applications: decentralised energy transactions, renewable energy provenance, metering and billing

## AI / Machine learning

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Example applications: enhanced forecasting models, new insights into large operational asset data sets

## Platform Business

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Example applications: data sharing between asset owners, operators, regulators and investors, automated wind resource assessment

## Drones and remote sensing

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Example applications: enhance safety through use of drones for wind turbine inspections, mapping using satellite data

## Mobile connectivity and tablet devices

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Example applications: mobile and tablet devices to standardise field-based workflow and automate data collection

## Big Data and data management

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Example applications: benchmarking of asset performance, application of machine learning across large numbers of diverse assets.

## API and SaaS

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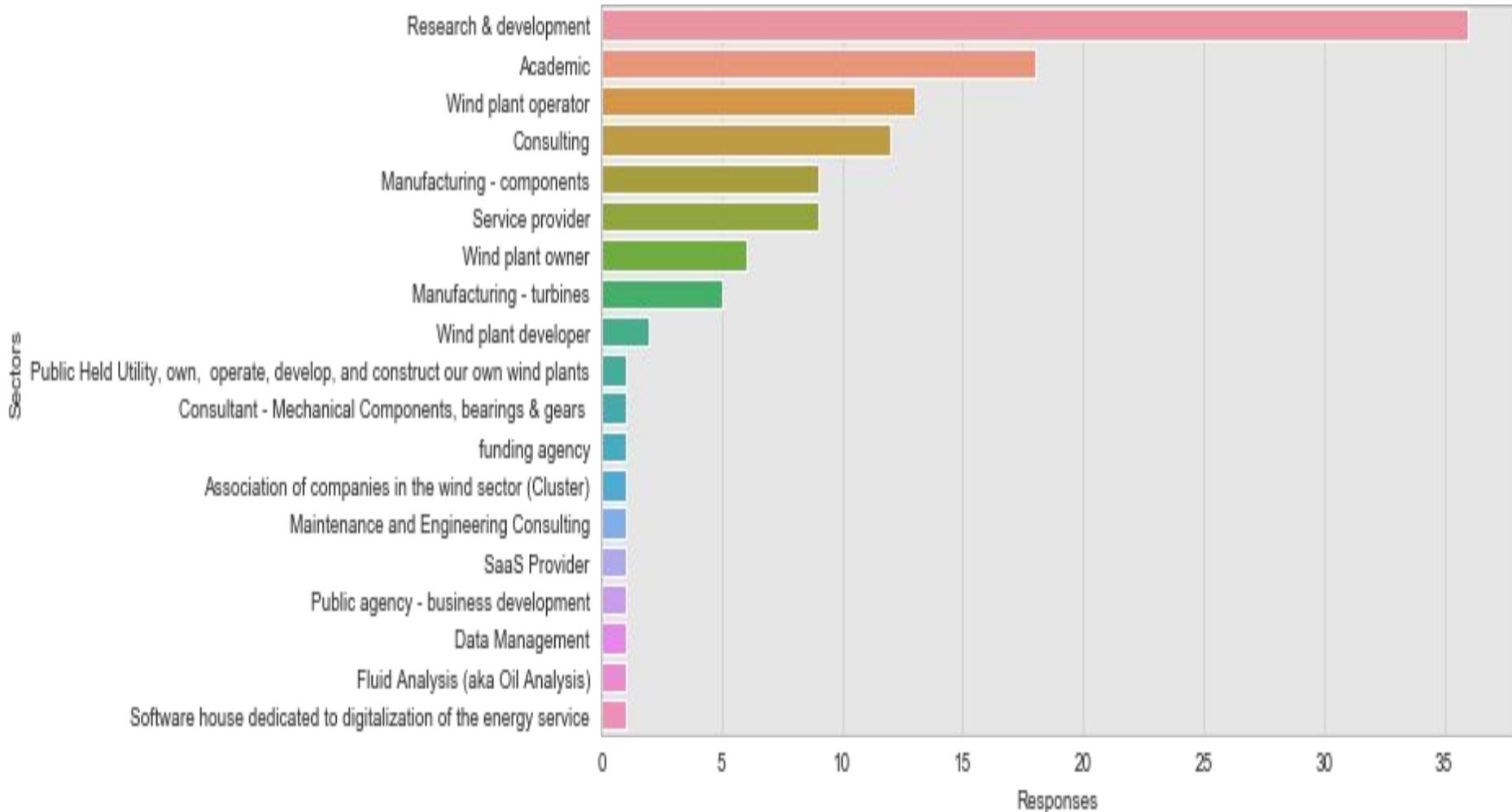
Example applications: engineering and analytical models provided and shared between stakeholders enabling enhanced cooperation between stakeholders

## Digital Twins

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Example applications: wind turbine digital twin for remaining life calculations, failure and reliability forecasts

# IEA Digitalization Survey (n=120)



# Thank You!!

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[Jason.fields@nrel.gov](mailto:Jason.fields@nrel.gov)

The IEA Wind TCP agreement, also known as the Implementing Agreement for Co-operation in the Research, Development, and Deployment of Wind Energy Systems, functions within a framework created by the International Energy Agency (IEA). Views, findings, and publications of IEA Wind do not necessarily represent the views or policies of the IEA Secretariat or of all its individual member countries.