Digitalization Mitigates Climate Change and Moves Us to a Sustainable Future

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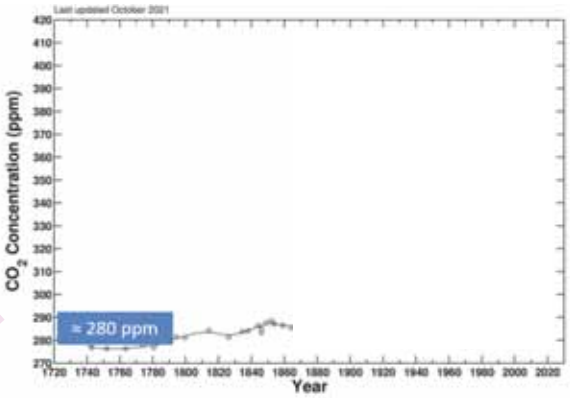
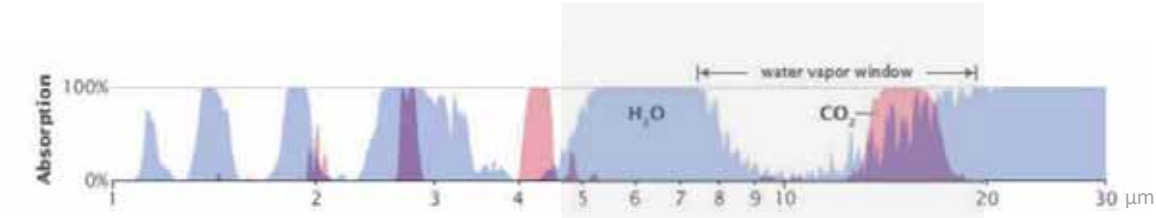
https://www.scjohnson.com/de-de/a-family-company/architecture-and-tours/living-planet-an-sc-johnson-company-sponsored-film-brought-a-birds-eye-view-of-nature-to-millions

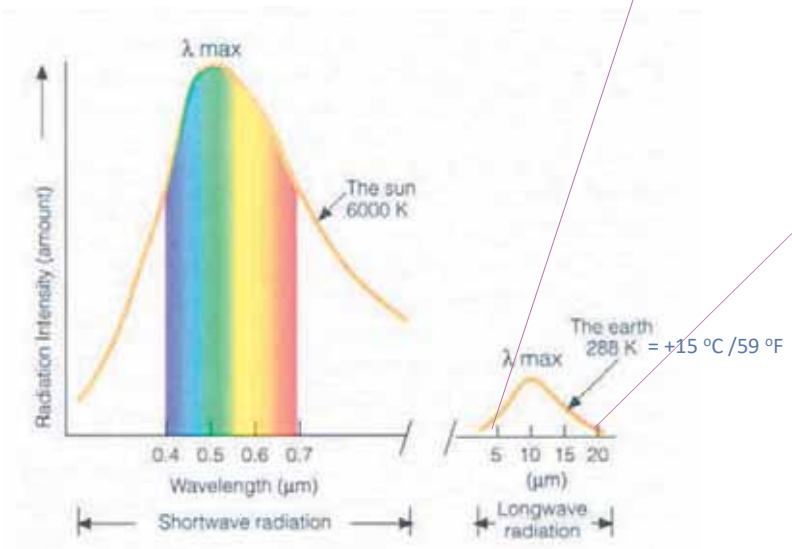
Digitalization Mitigates Climate Change

- The natural greenhouse effect
- Man-made climate change
- Digital innovation in the power sector
- System integration and efficiency increase
- Outlook



Graphics: What is Climate Change? - Golden Gate National Recreation Area (U.S. National Park Service) (nps.gov)



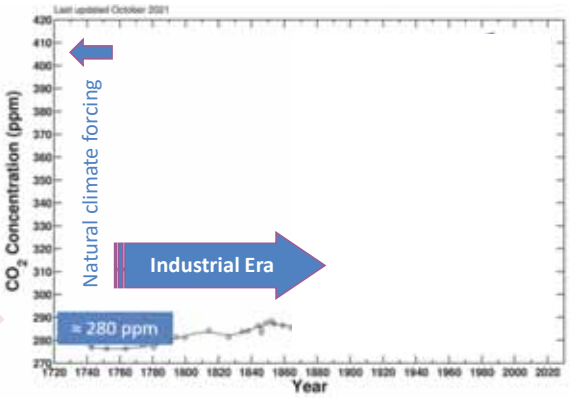


H_2O : 0…4% in atmosphere

CO_2 : 0,04% in atmosphere (280 ppm)

- outgassing oceans
- decomposing vegetation
- other biomass…

But then, after more than 800,000 years, the industrial era started with its ever growing need for energy from coal, oil, and gas…



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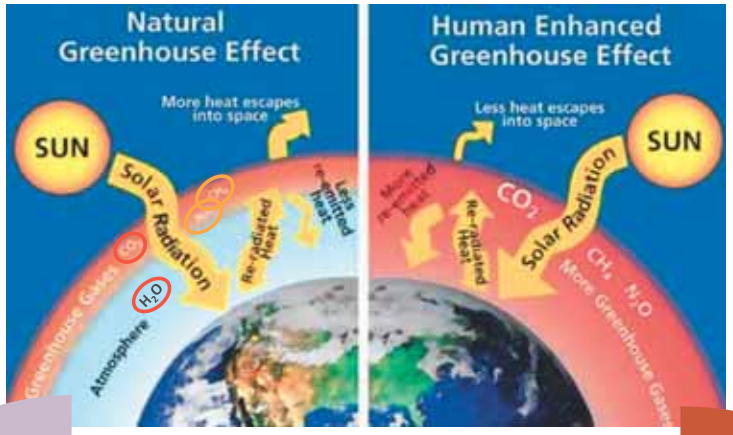
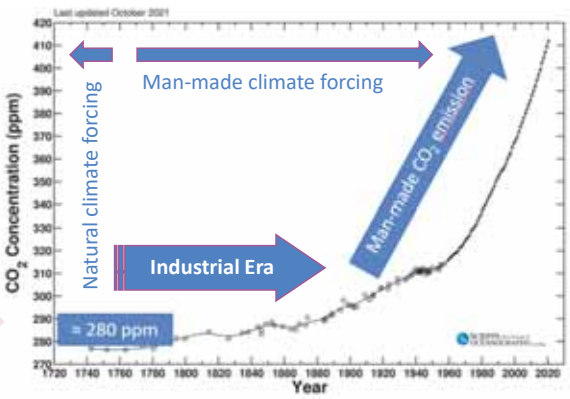


Result: increasing CO_2 beyond the equilibrium
→ imbalance → warming
→ more H_2O
→ positive feedback loop!



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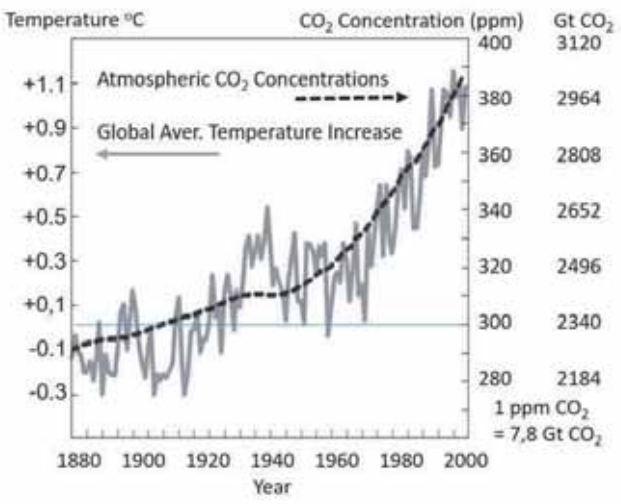
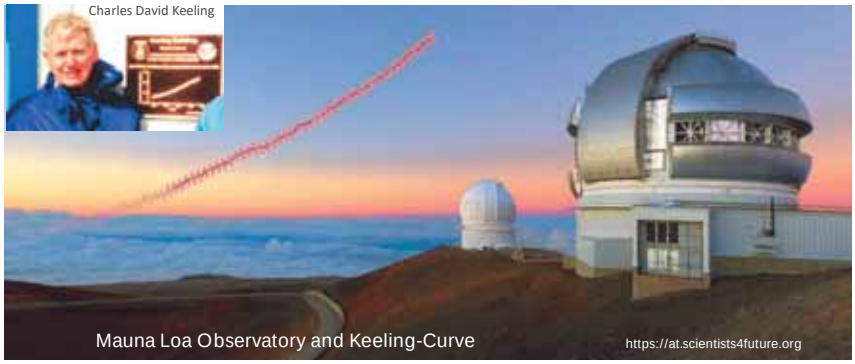
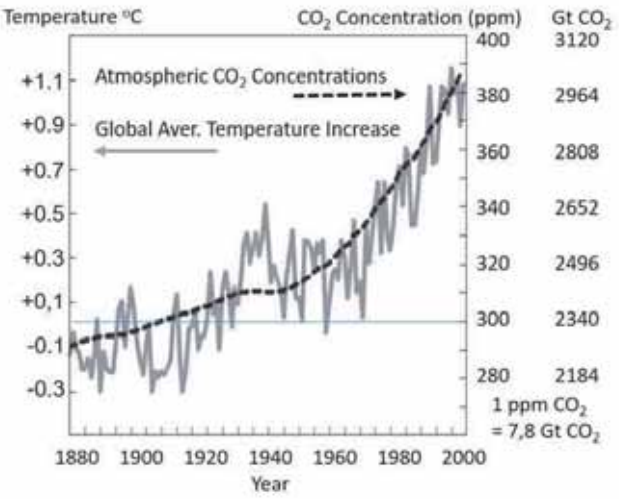


https://data.giss.nasa.gov/gistemp/graphs_v4/



Keeling photo: https://pubs.acs.org/doi/10.1021/ac1001492#:~:text=Keeling%20decided%20that%20he%20needed,its%20concentration%20with%20his%20manometer.



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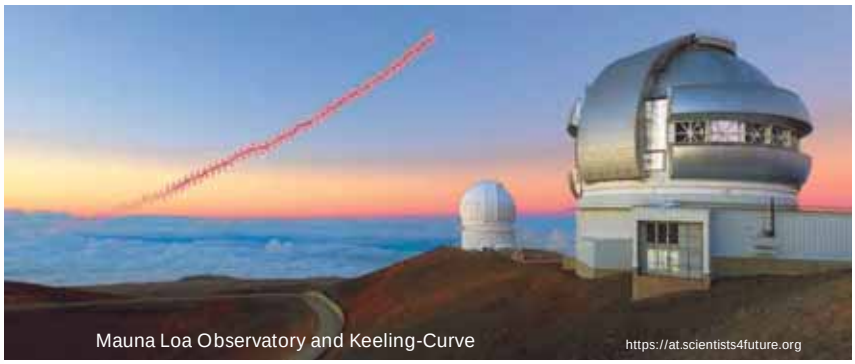


Anthropogenic annual CO_2 emissions (2011-20) :

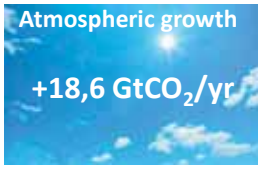
Sources:

Fossil fuels & Industry

Land use change

38.9 $GtCO_2$ /yr

≈
Small Budget imbalance!

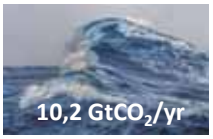


18,6 $GtCO_2$/yr

Sinks:

Land sink

Ocean sink

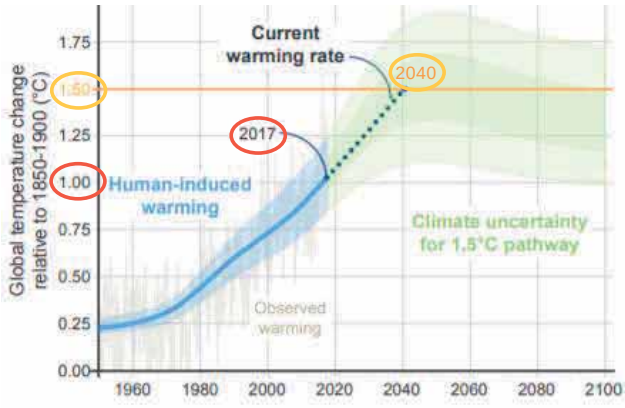


+

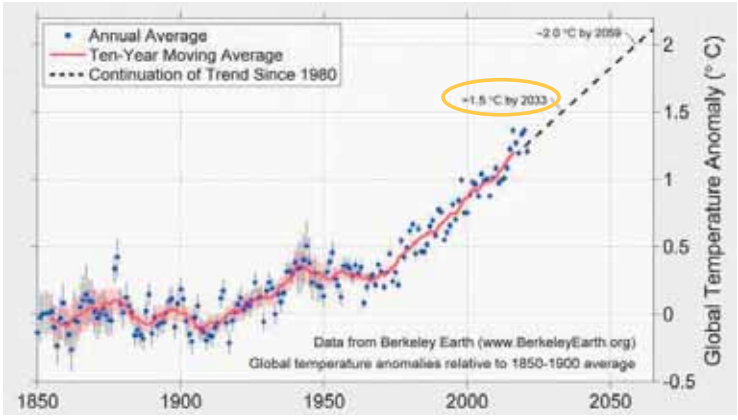
21,4 $GtCO_2$/yr

GCP_CarbonBudget_2021

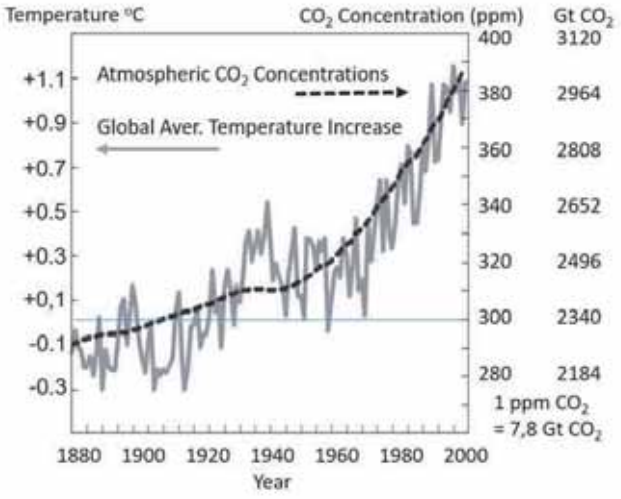
Human-induced warming reached 1°C above pre-industrial levels in 2017 and 1,5 °C was predicted for 2040…more recent data indicate 2033!



Extrapolated from the increase rate of 2017 , global temperatures would reach 1.5°C around 2040.



Source: Florida Today



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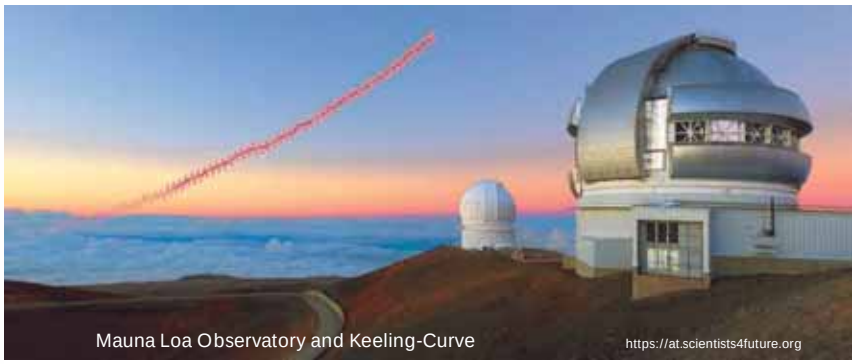


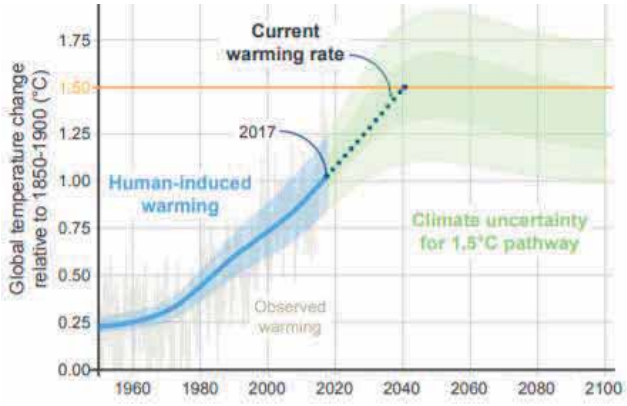
Factorizing man-made CO_2 emission:

Total CO_2 Emission = **Population** x **GDP/Population** *per Capita Economic Activity* x **Energy/GDP** *Energy Intensity* x **CO_2 /Energy** *Carbon Intensity*

Kaya identity

„Bend the curve to protect the climate!“

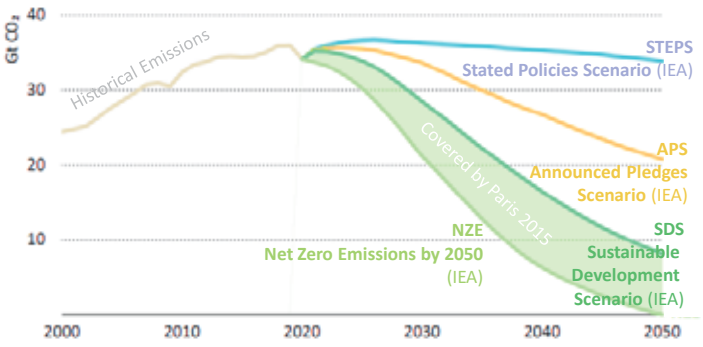
Pathways / scenarios to save the planet from (over)heating:
Use the levers in the Kaya identity – energy efficiency↑ and carbon intensity↓ !



IPCC*) SPECIAL REPORT **Global Warming of 1.5 ºC, 2018** ***) IPCC : Intergovernmental Panel on Climate Change**

Stylized 1.5°C pathway shown here assumes emission reductions beginning immediately, and CO_2 emissions reaching zero by 2050.

CO_2 emission mitigation in IEA*) World Energy Outlook 2021 scenarios



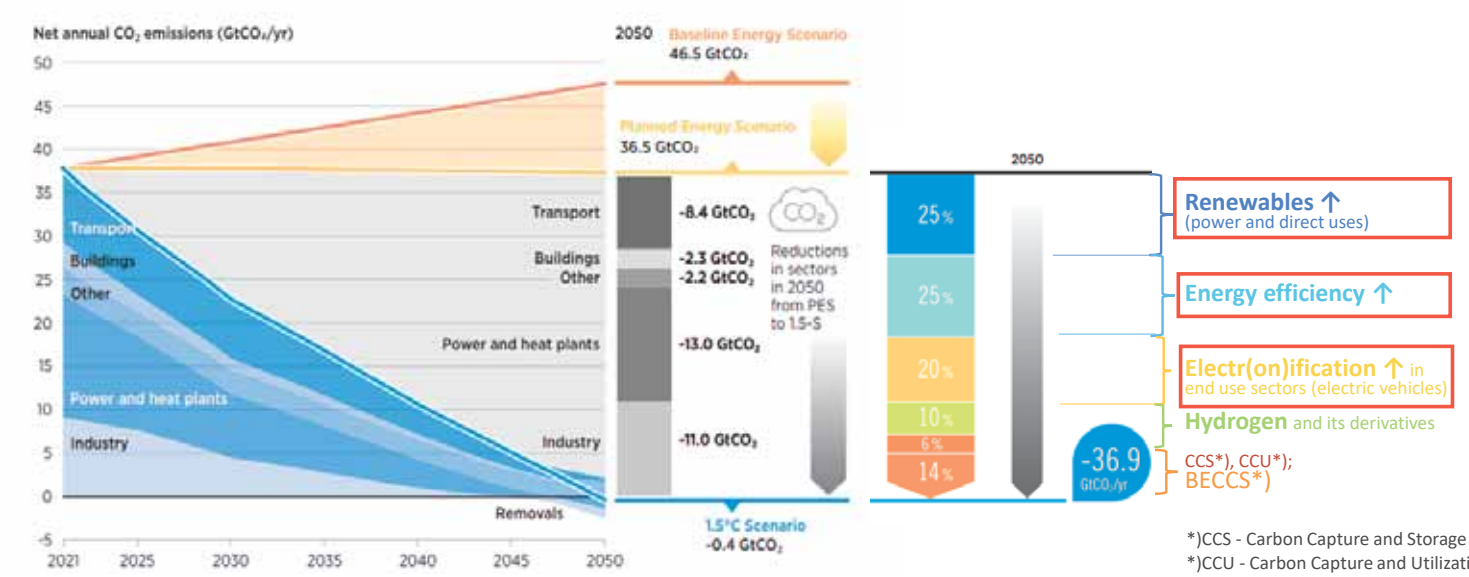
*) IEA: International Energy Agency, intergovernmental organization in the framework of OECD

PARIS2015
COP21-CMP11

The purpose of the agreement is to hold the increase in global average temperature to well below 2°C above pre-industrial levels and to ensure that efforts are pursued to limit the temperature increase to 1.5 °C

Sector wise energy related CO_2 emission reduction according to the IRENA*) 1.5 °C scenario… … and three main levers enabling mitigation (2021-2050)

*) IRENA: International Renewable Energy Agency (Intergovernmental organization)



*)CCS - Carbon Capture and Storage
*)CCU - Carbon Capture and Utilization
*)BECCS – Bioenergy with CCS

IRENA Planned Energy Scenario (PES)
cf. IEA´s STEPS (Stated Policies Scenarios)
IRENA 1.5°C Scenario (1.5-S)
cf. IEA´s NZE (Net Zero Emission Scenarios)

Adapted: IRENA_World_Energy_Transitions_Outlook_2021

Sector wise energy related CO_2 emission reduction according to the IRENA*) 1.5 °C scenario… … and estimated associated total cost according to McKinsey (comparable scenarios)……

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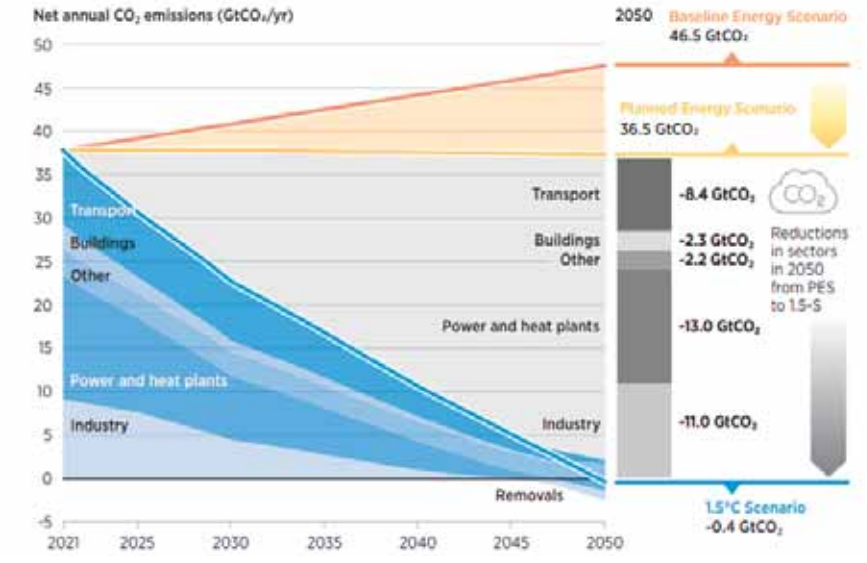
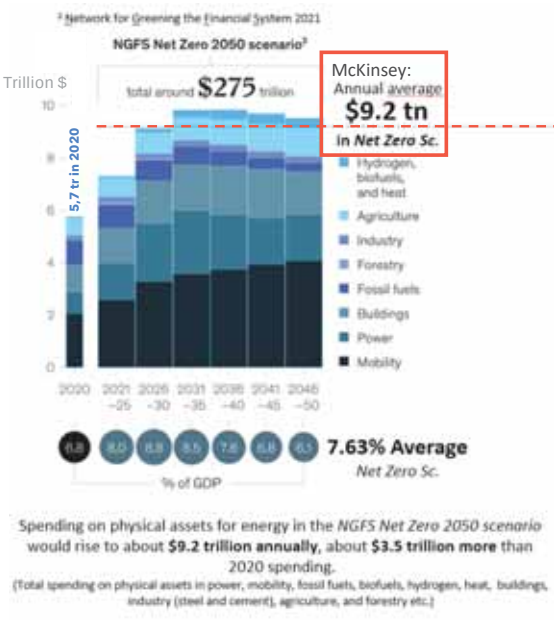
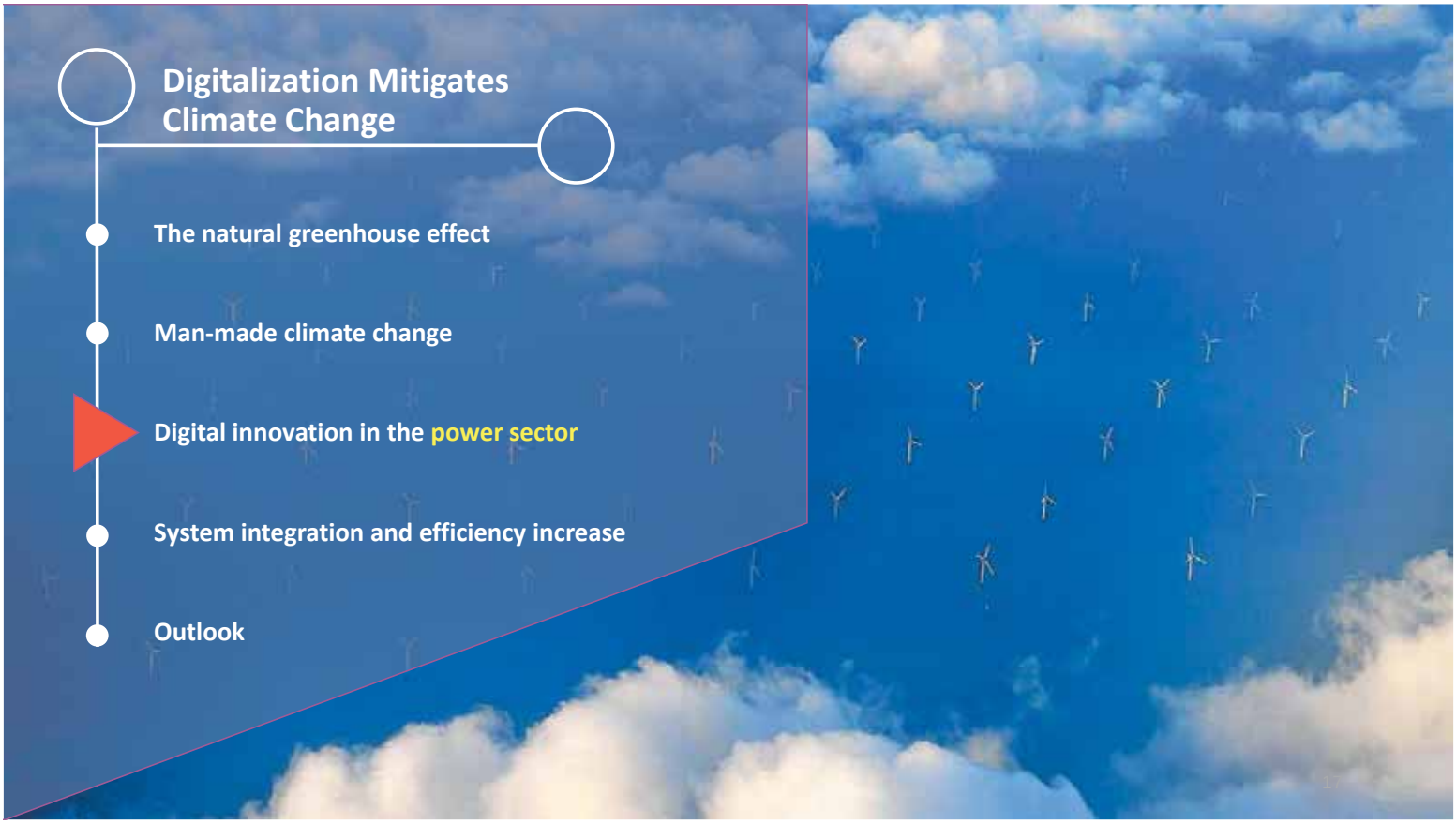




Adapted: IRENA_World_Energy_Transitions_Outlook_2021 ; McKinsey The net-zero transition Jan. 2022

GLASGOW, Nov 3, 2021 (Reuters): *Banks, insurers and investors with **$130 trillion ($4,3 tn annual average)** at their disposal pledged on Wednesday to put combating climate change at the center of their work (COP 26).*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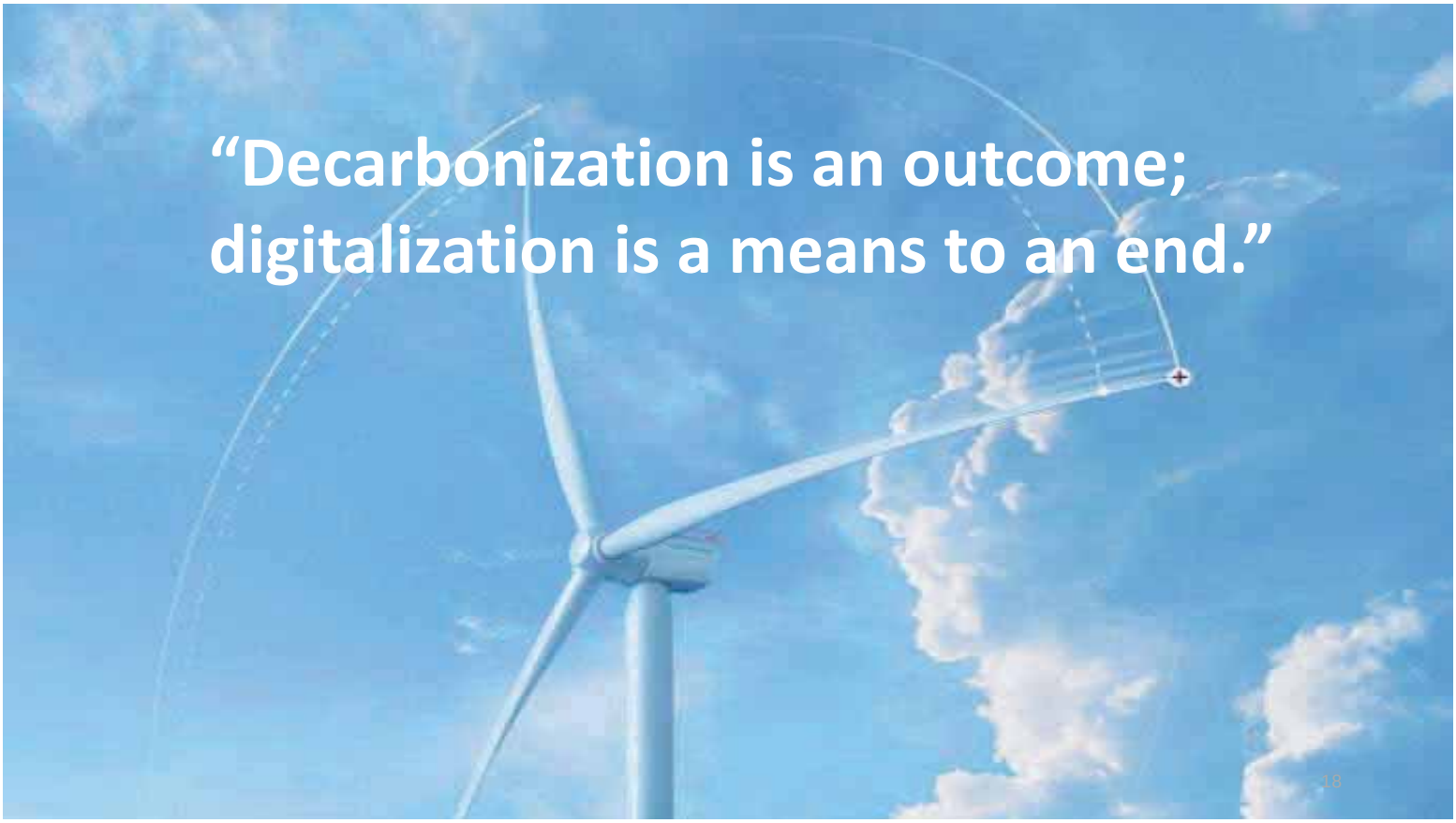
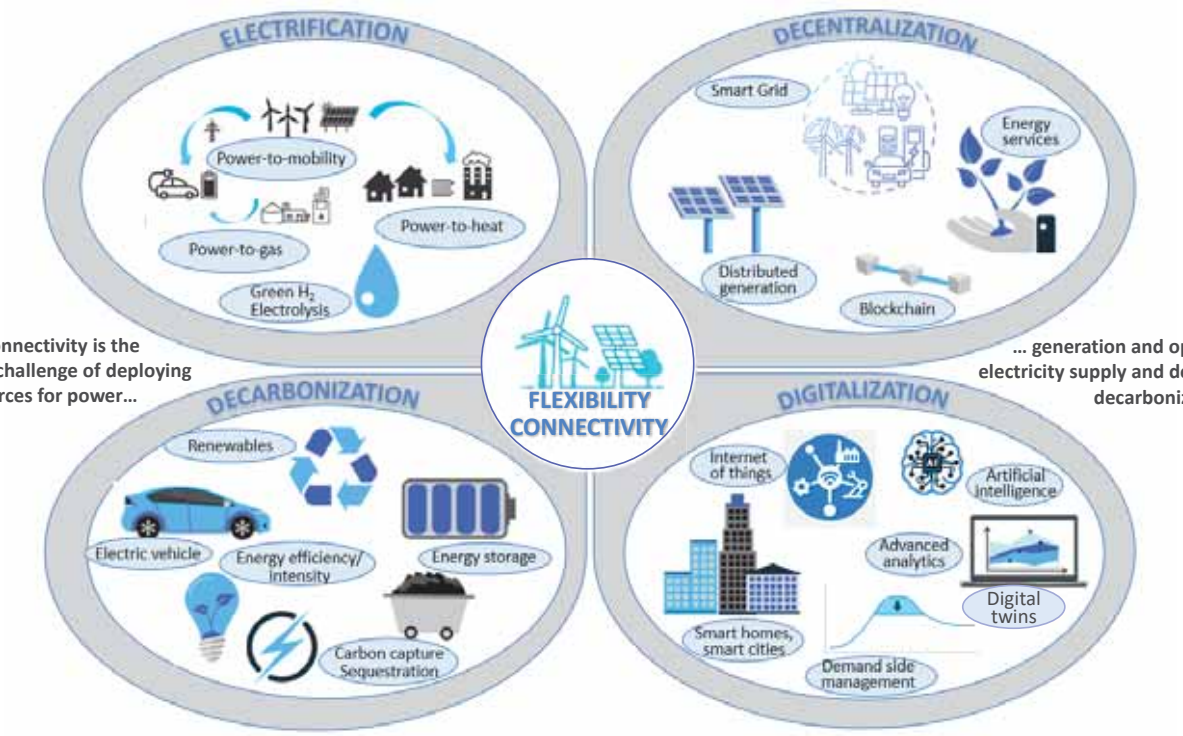

“Decarbonization is an outcome; digitalization is a means to an end.”

Electrification, Decentralization and Decarbonization are Key to Mitigating Climate Change…
…but full Flexibility is only achieved by Digitalization and Connectivity

Flexibility & Connectivity is the answer to the challenge of deploying renewable sources for power…



… generation and optimizing the electricity supply and demand as we decarbonize our world.

Adapted from McKinsey: Global Energy Trends and country responses Workshop document, Dec. 2020

Emerging digitally enabled innovations in the power sector: integration of solar and wind power

adapted from IRENA Innovation Landscape 2019

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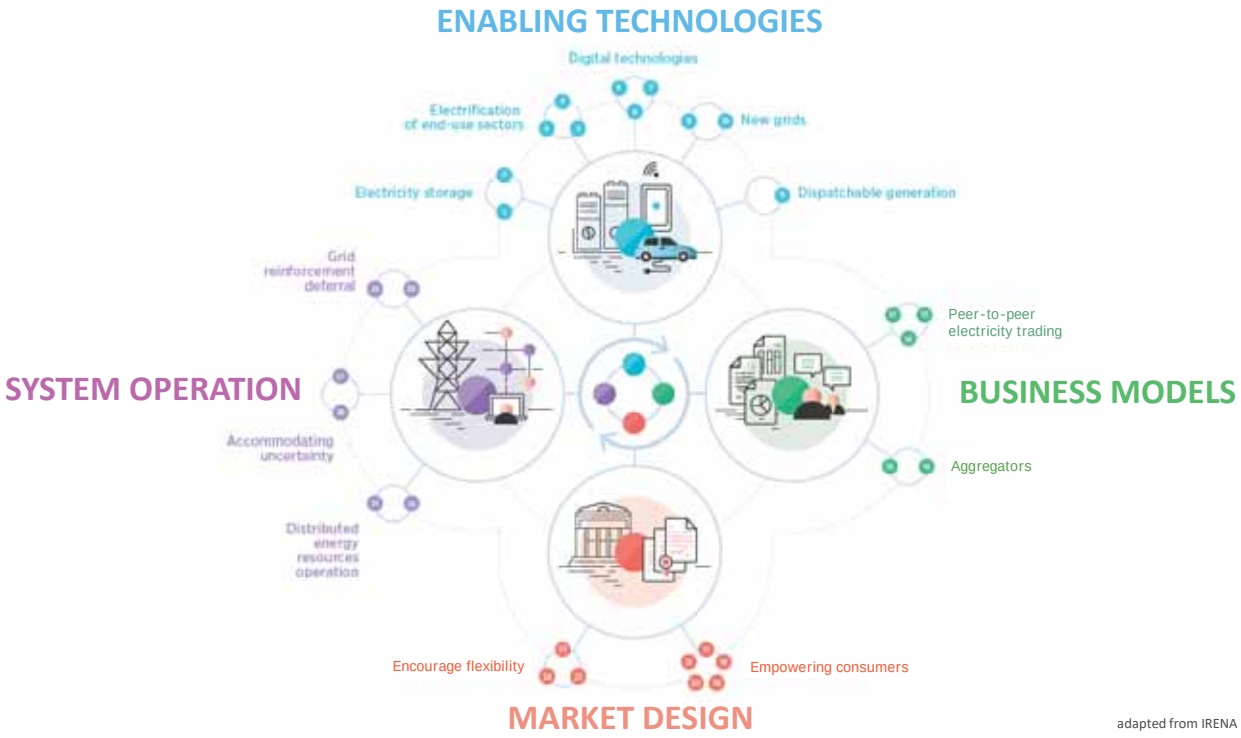
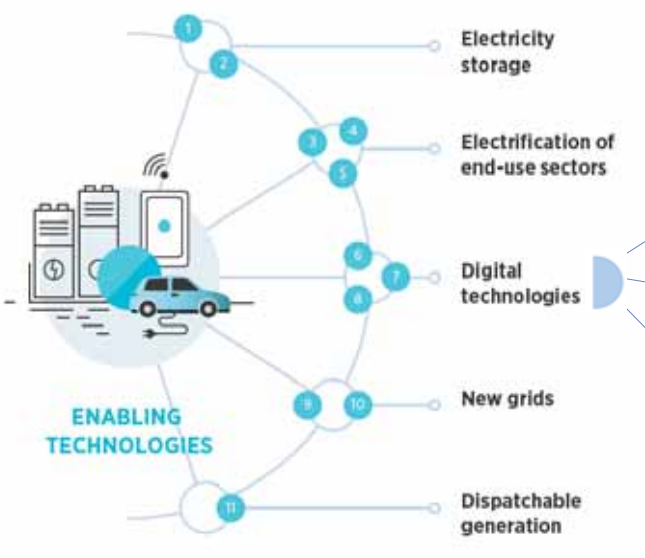


adapted from IRENA Innovation Landscape 2019

Enabling Technologies

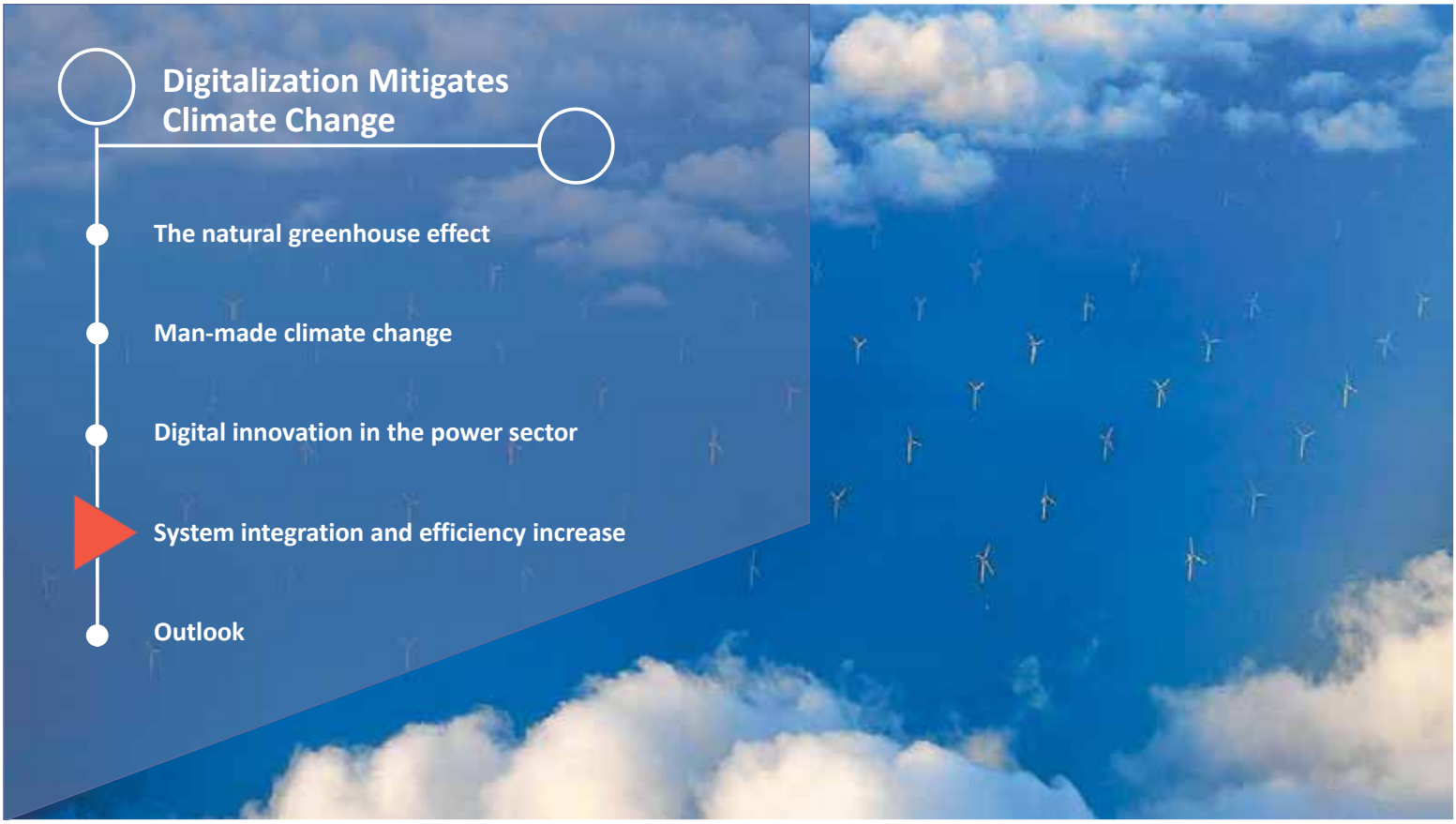


6 - INTERNET OF THINGS
The IoT enables real-time communication through the Internet among devices **in homes, commercial and industry facilities**. It increases **system flexibility** by enabling (remotely managed) rapid automatic changes **in renewable distributed resources.**

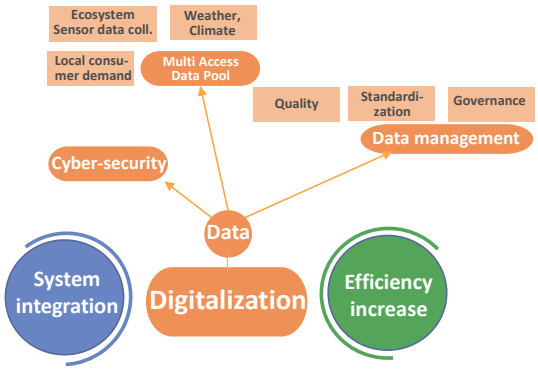
7 - ARTIFICIAL INTELLIGENCE AND BIG DATA
The combination of AI and Big Data helps integrating Variable Renewable Energy (VRE) in the power system by **increasing the accuracy of VRE generation forecasting**, **improving system operation** and **asset management** through remote monitoring, analysis and maintenance. Using AI can achieve **up to 10% CO_2 reduction** (BCG, 2022).

8 – BLOCKCHAIN
…the distributed ledger technology can be used to securely record all transactions taking place on a given network. It facilitates **direct trading** and sharing of verifiable information and enables **decentralized** flexible energy **sources** to **provide service** to the electricity grid. It opens new markets for **transactions with certified products** with a trustable energy footprint.

adapted from IRENA Innovation Landscape 2019



Digitalization: The Backbone for System Integration and Efficiency Increase in the Deployment of Renewables



Digitalization can be defined as converting **data into value** for the power sector.

Data collection from **sensors** and **data exchange** between **renewable energy operators** and the **surrounding ecosystem (e.g., managing, forecasting, trading…)** is **essential**. Making use of this data will unlock **new horizons of productivity**.

Adapted: European Technology & Innovation Platform on Wind Energy

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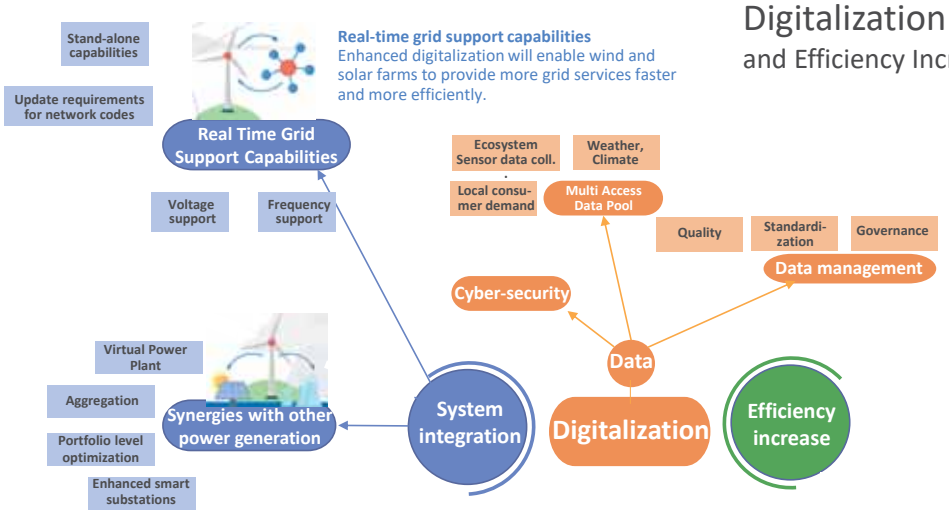

Real-time grid support capabilities
Enhanced digitalization will enable wind and solar farms to provide more grid services faster and more efficiently.

Synergies with other power generation
Digital solutions connect renewable power plants with other power generators, facilitating system-level energy management.

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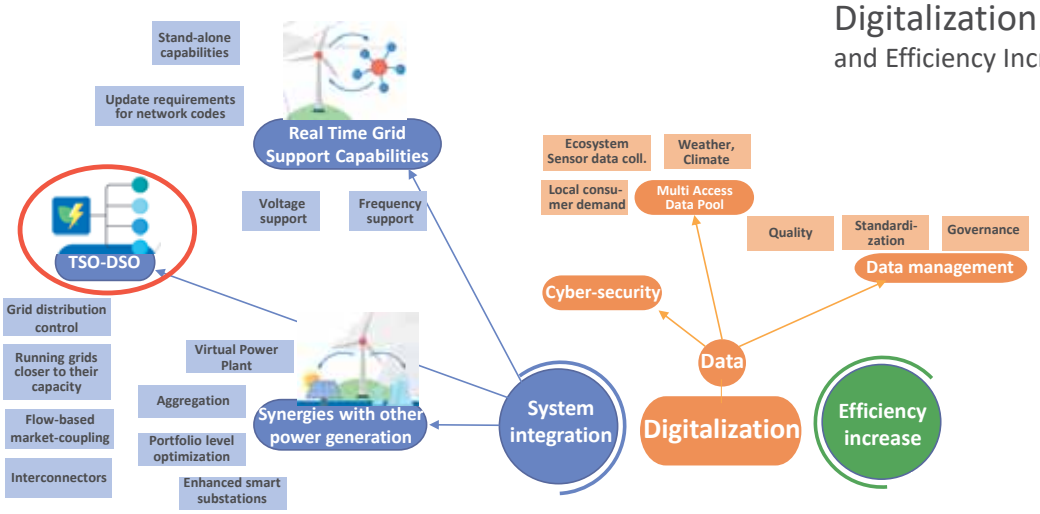

TSO-DSO (**T**ransmission **S**ystem **O**perators – **D**istributed **S**ystem **O**perators)

For the conventional grid industry, the introduction of renewables amounted to a revolution. Electrical grids around the world were originally designed to transport and deliver power from synchronously connected generators safely, reliably and efficiently. The traditional electricity supply chain followed a very simple rule: energy flowed **unidirectionally** from generation, via transmission and distribution to the consumer and vice versa the customer´s money flowed back.

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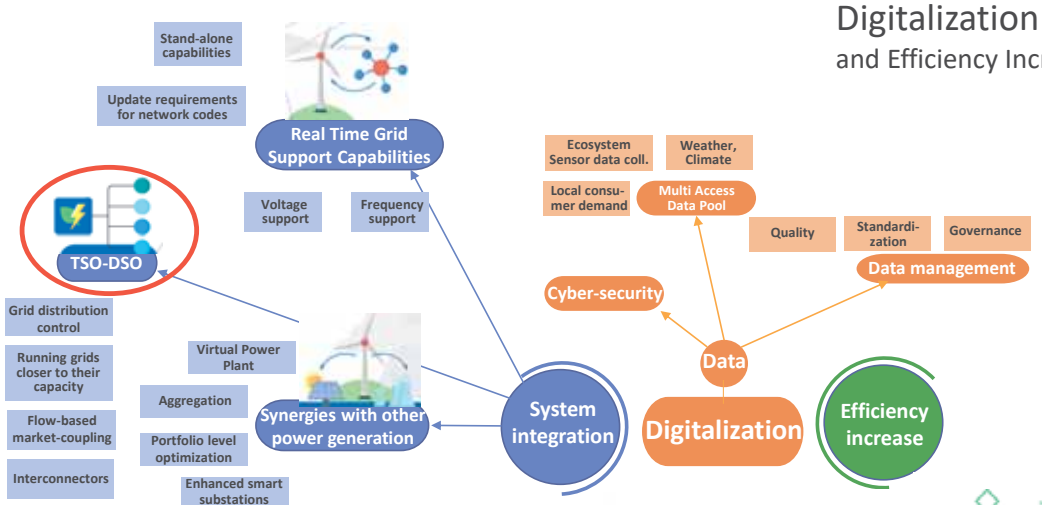
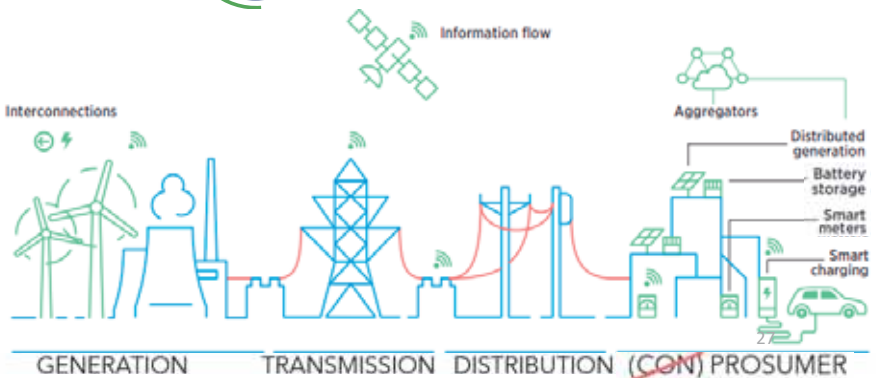


TSO-DSO (Transmission System Operators – Distributed System Operators)

As decentralized renewables feed into distribution grids, and the electrical system becomes fit for remote digital control, demand management, smart meters, smart charging of electrical vehicles, battery technology in households, transmission and distribution grids acquire **bidirectionality**.
Where power used to flow from major generators to consumers, now active energy consumers, or 'prosumers', both consume and produce electricity and feed power back into the grid.



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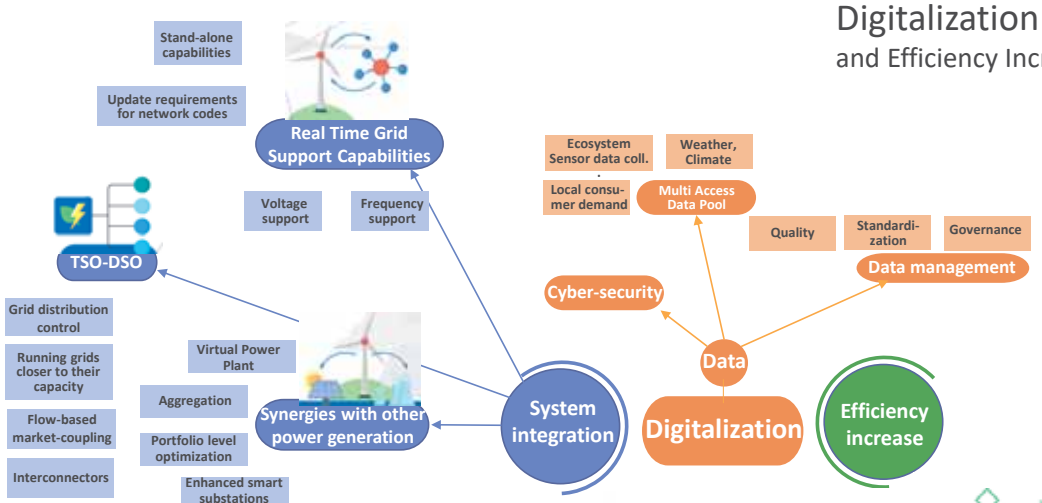
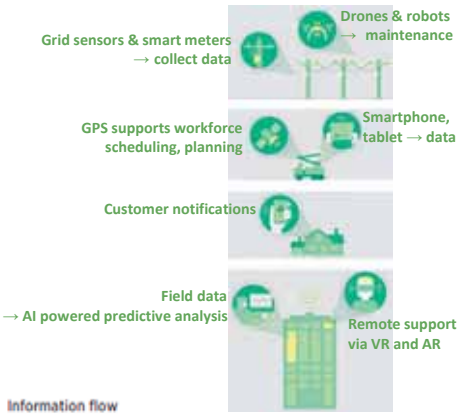
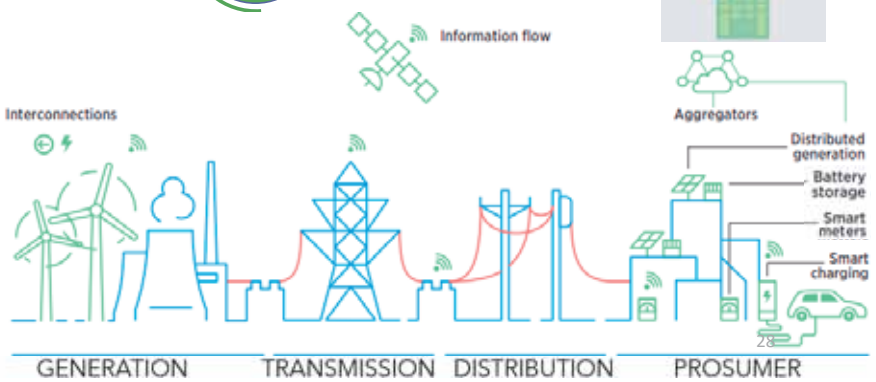




TSO-DSO (Transmission System Operators – Distributed System Operators)

More and higher quality data exchanges between system operators and renewable power generators will improve the transmission and distribution of clean energy throughout the grid...
...and the electricity grids themselves must be tweaked to cope because green power needs more than just solar panels and wind turbines!



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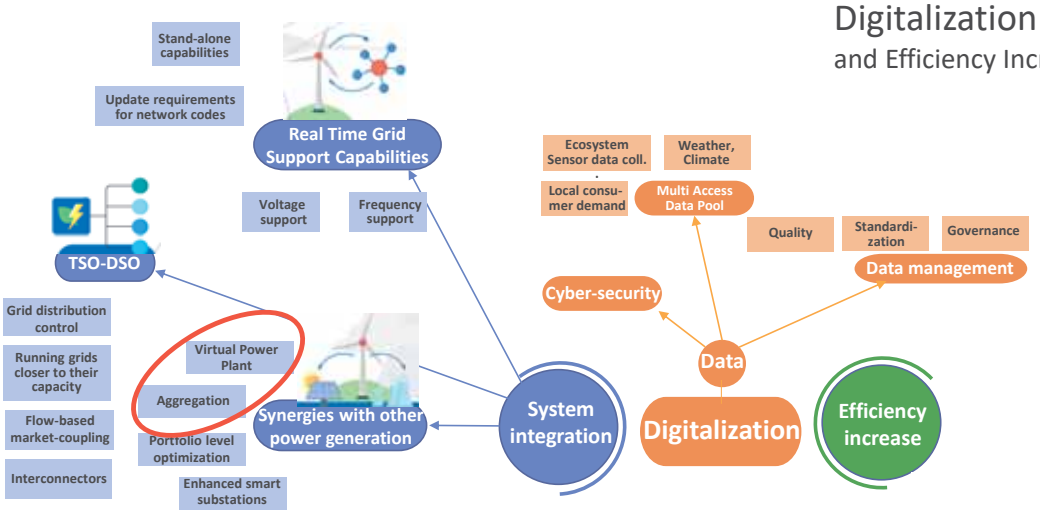

Virtual power plants /Aggregators
Distributed energy owners benefit from aggregations of behind-the-meter energy storage , backup power, resource optimization, and grid service revenues.

Electric vehicles charge on solar power at Google's headquarters in Mountain View, Calif. Such distributed energy assets are becoming building blocks for virtual power plants.

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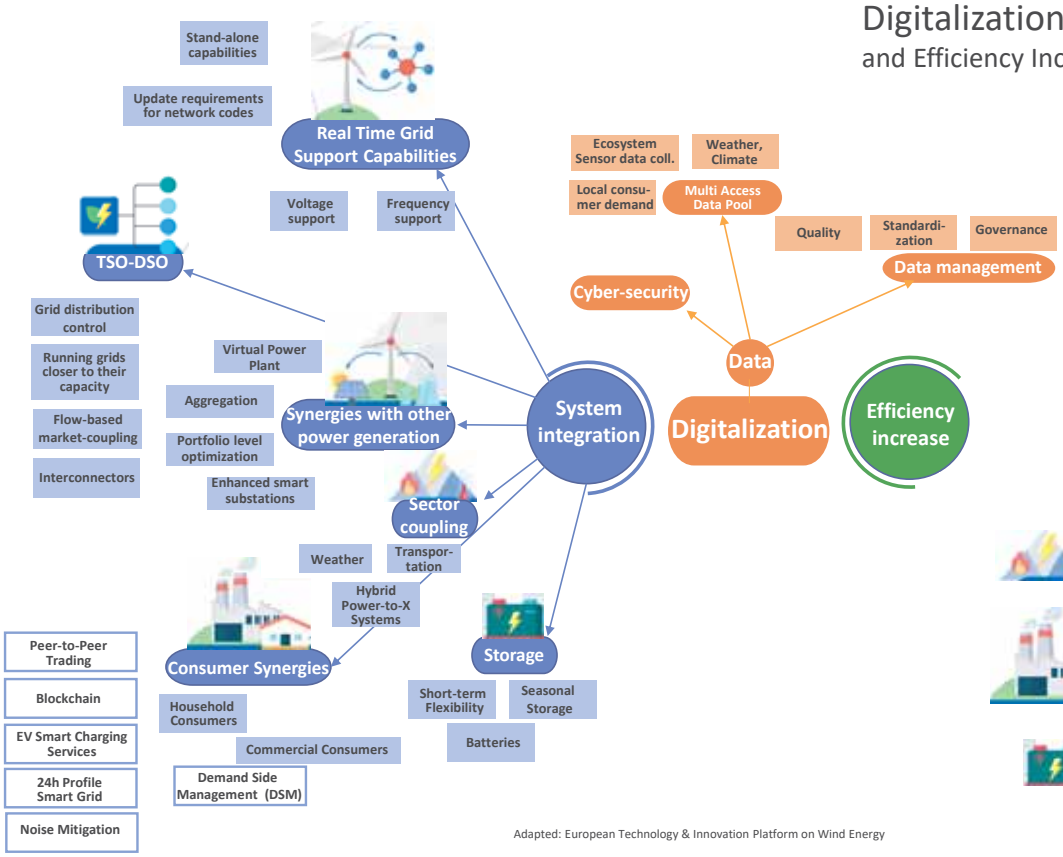

Sector coupling
Increased digitalization offers opportunities to strengthen and develop synergies between the electricity sector and other energy carriers.

Consumer synergies
Digitizing electricity consumption and demand-side management (DSM) will improve consumers' connectivity and interactivity with power generators. "Instead of flexibly adapting electricity supply to demand, DSM flexibly adapts consumption to availability of electricity."

Storage
Innovative systems coupling generated power and storage will enhance the intermittent renewables´ ability to become a crucial part of the energy system.

Adapted: European Technology & Innovation Platform on Wind Energy

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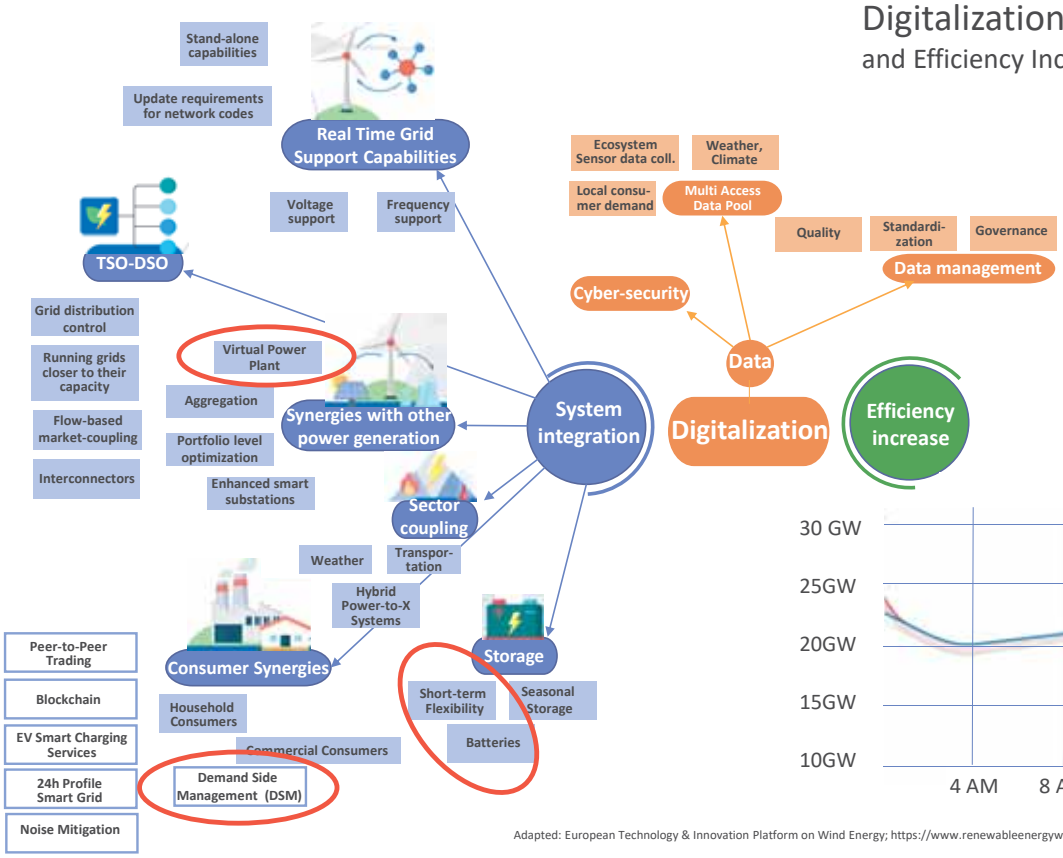
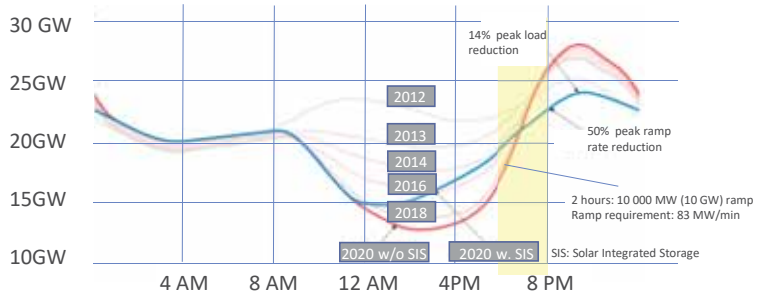


Accelerated uptake of distributed renewables (solar) changes the utility load curve. The transformation of the originally "flat" (2012) power station load curve to the red **"duck curve"** shaped load in 2020 is shown. Unabated, solar PV uptake leads to the formation of the duck´s ventral part and the development of a steep ramp (which is difficult to control). With deployment of **intelligent storage and digital control** of the consumed capacity, the **steep ramp rate** of more than 80 MW/min **is halved** and the **peak load is reduced** (blue curve).
This is an example for **Demand Side Management.**
To be effective, such systems must allow storage assets to be dynamically aggregated, capacity tailored to suit the specific needs of the grid, and their control orchestrated in concert as if they were a single **Virtual Power Plant**.



Adapted: European Technology & Innovation Platform on Wind Energy; https://www.renewableenergyworld.com/storage/integrated-energy-storage-an-answer-to-addressing-the-duck-curve

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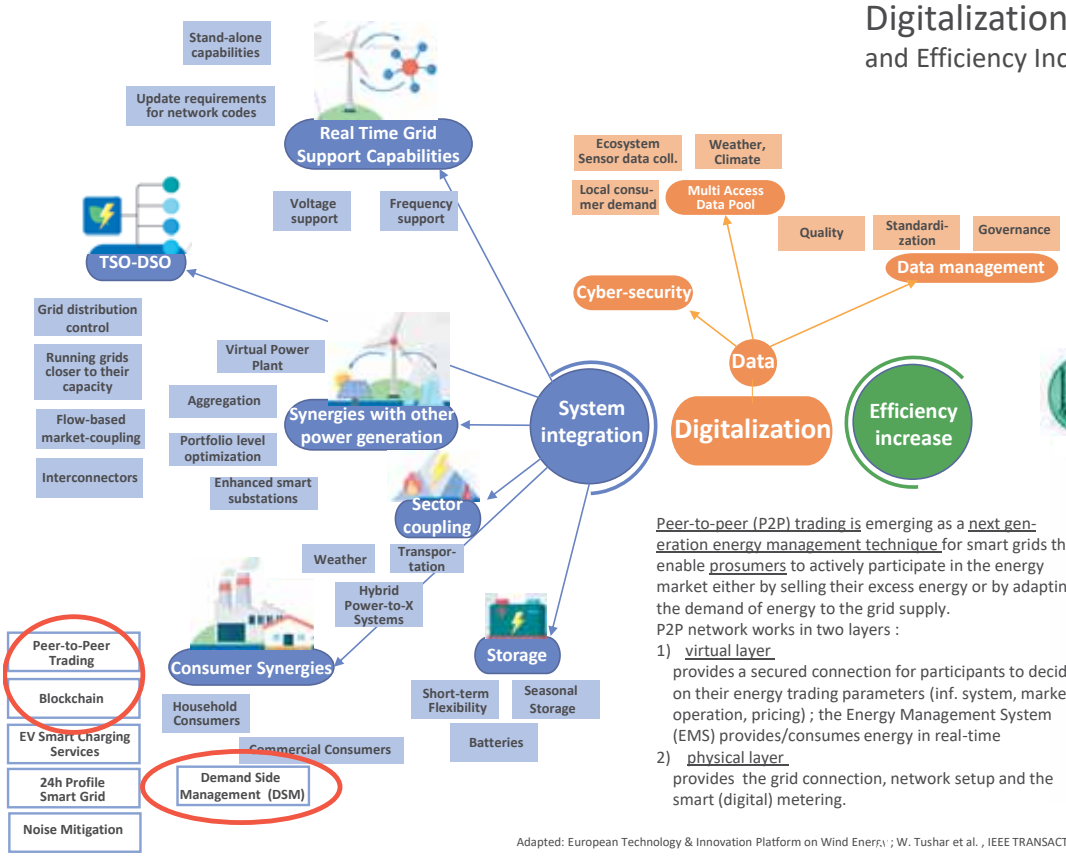
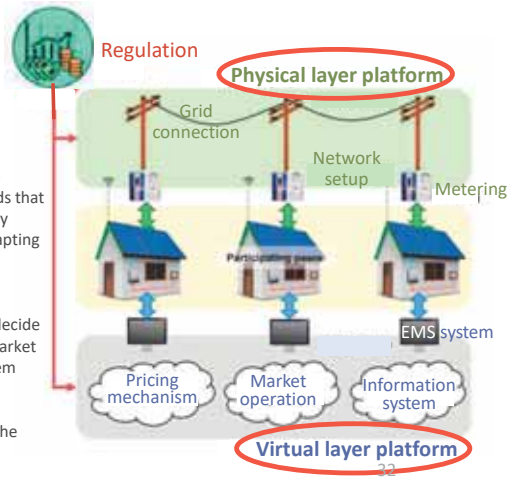


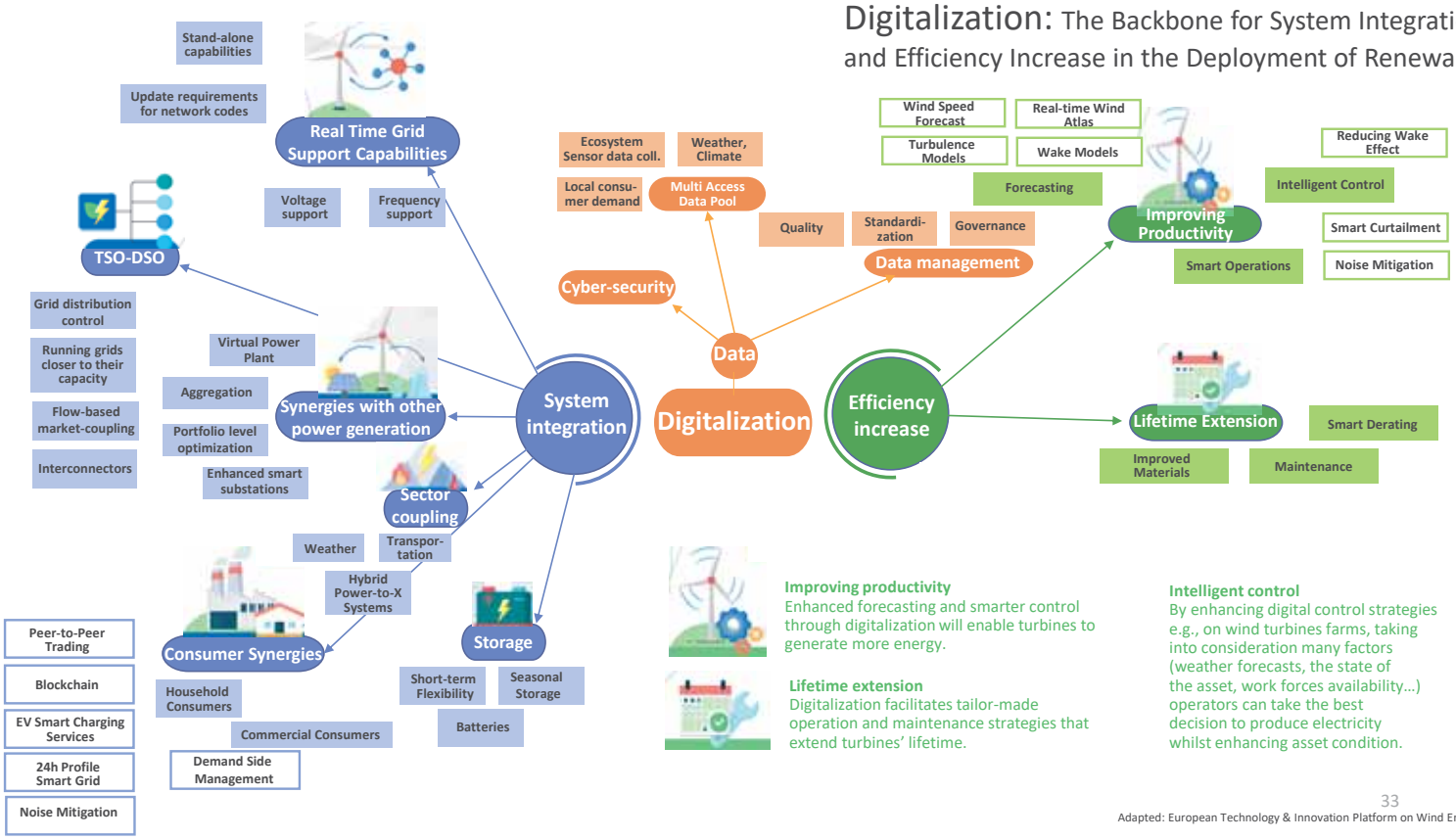
Peer-to-peer (P2P) trading is emerging as a next gen-eration energy management technique for smart grids that enable prosumers to actively participate in the energy market either by selling their excess energy or by adapting the demand of energy to the grid supply.
P2P network works in two layers :

1) virtual layer
provides a secured connection for participants to decide on their energy trading parameters (inf. system, market operation, pricing) ; the Energy Management System (EMS) provides/consumes energy in real-time
2) physical layer
provides the grid connection, network setup and the smart (digital) metering.



Adapted: European Technology & Innovation Platform on Wind Energy ; W. Tushar et al. , IEEE TRANSACTIONS ON SMART GRID, VOL. 11, NO. 4, JULY 2020

Digitalization: The Backbone for System Integration and Efficiency Increase in the Deployment of Renewables



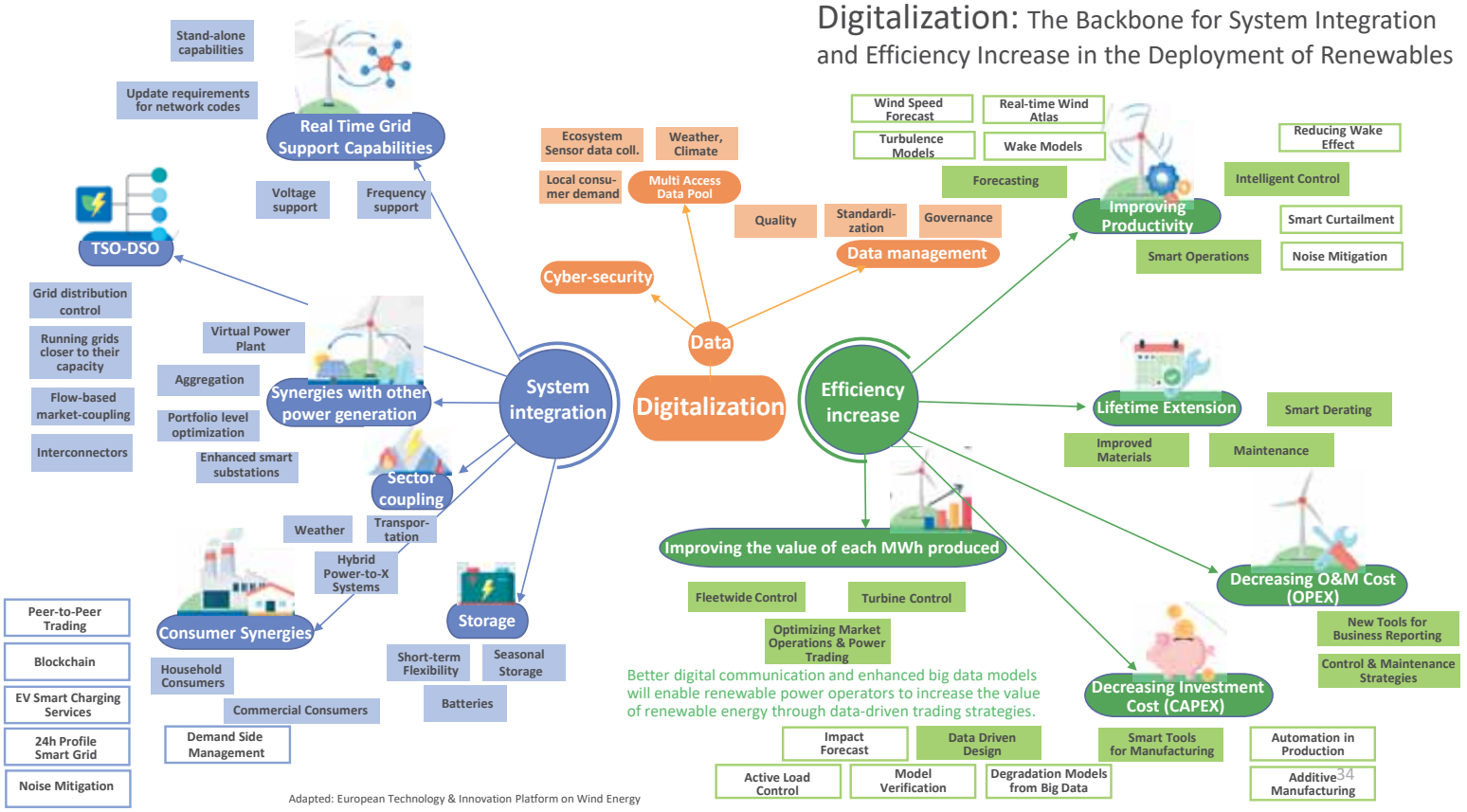
Improving productivity
Enhanced forecasting and smarter control through digitalization will enable turbines to generate more energy.

Lifetime extension
Digitalization facilitates tailor-made operation and maintenance strategies that extend turbines' lifetime.

Intelligent control
By enhancing digital control strategies e.g., on wind turbines farms, taking into consideration many factors (weather forecasts, the state of the asset, work forces availability…) operators can take the best decision to produce electricity whilst enhancing asset condition.

Adapted: European Technology & Innovation Platform on Wind Energy

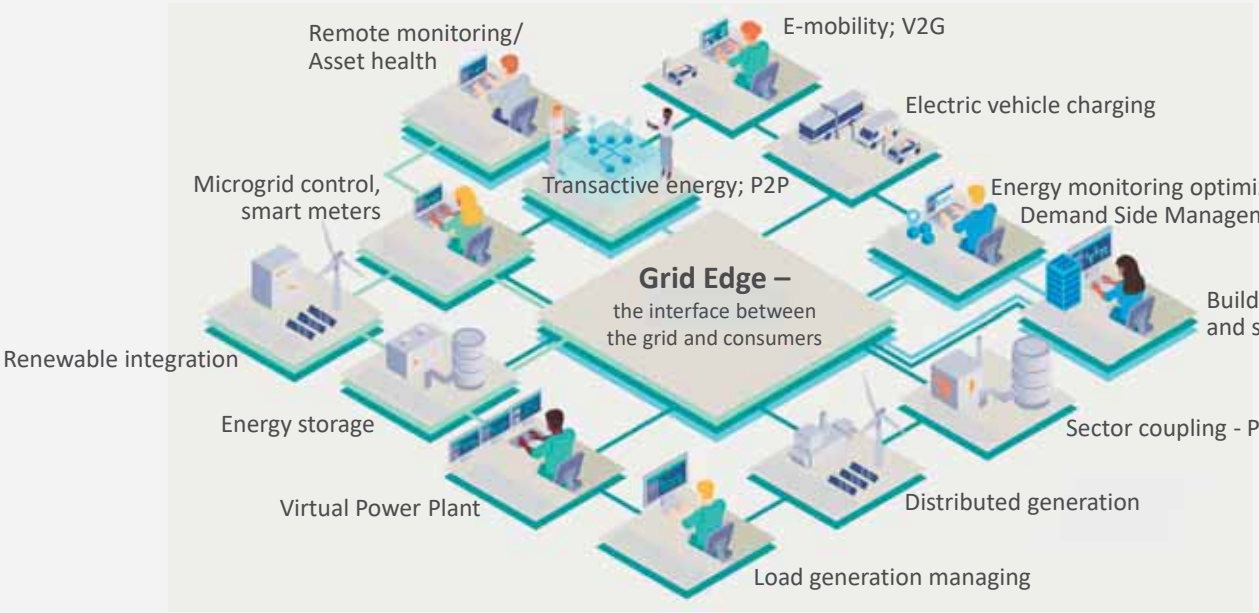
Digitalization: The Backbone for System Integration and Efficiency Increase in the Deployment of Renewables



Better digital communication and enhanced big data models will enable renewable power operators to increase the value of renewable energy through data-driven trading strategies.

Adapted: European Technology & Innovation Platform on Wind Energy

Grid Edge Technologies – Power Systems of the Future: All of them rely on digitalization and ICT!

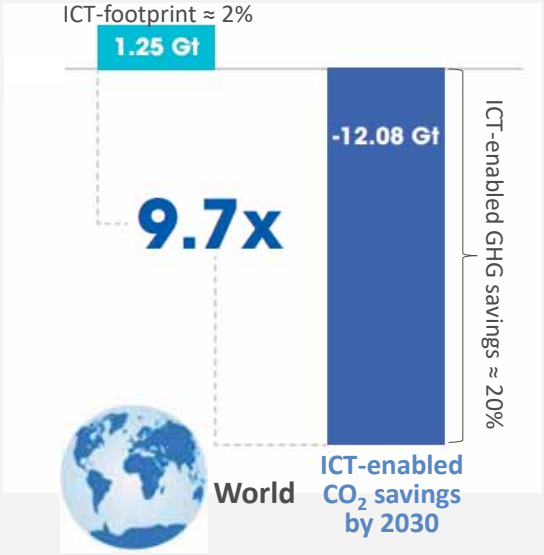


Adapted: https://new.siemens.com/de/de/unternehmen/themenfelder/smart-infrastructure/grid-edge.html

ICT technologies save much more CO_2 emissions than they produce (2030 estimation)

(World forecast 2015: Accenture and GeSI*)

*) Global enabling Sustainability Initiative



Possible CO_2 mitigation by digitalization:

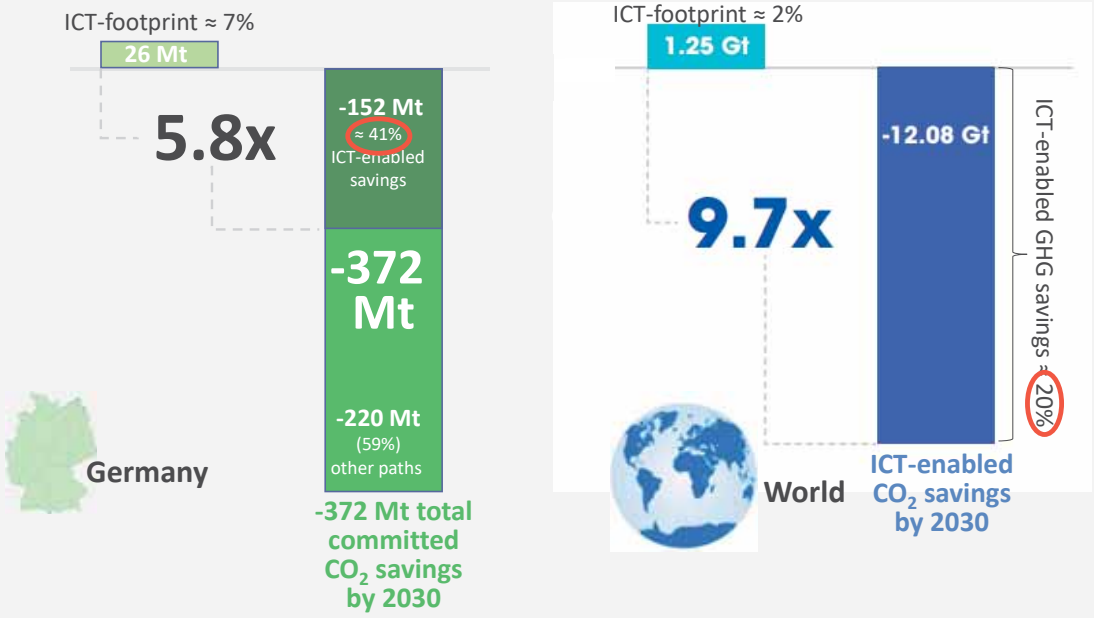
Energy (smart grids, renewable production)
Mobility (traffic control,intelligent logistics…)
Buildings (smart homes, networked buildings)
Industry (automation, digital twins…)
Work+Business (home&mobile working…)
Agriculture (livestock farming, land mgmt. ..)

Source: https://smarter2030.gesi.org

ICT technologies save much more CO_2 emissions than they produce (2030 estimation)

(Germany forecast 2019: Accenture; World forecast 2015: Accenture and GeSI*)

ICT used to be a sector. Now it is everywhere…



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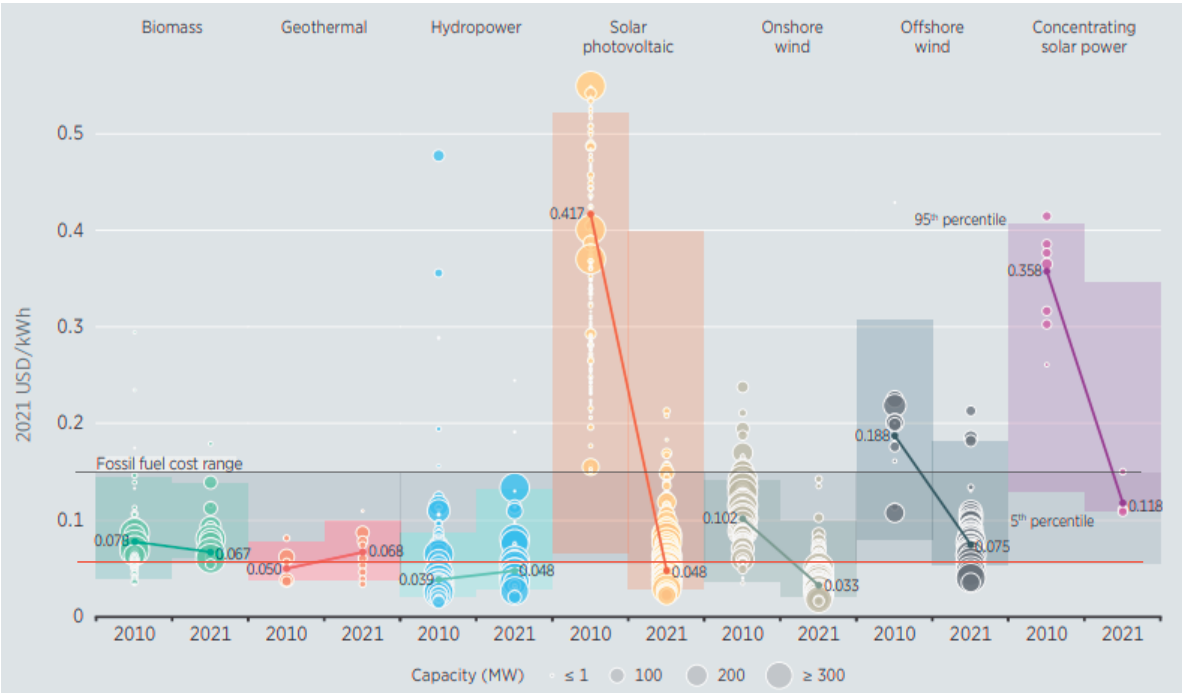
Adapted: https://www.accenture.com/de-de/insights/strategy/klimaeffekte-digitalisierung 2019

Source: https://smarter2030.gesi.org

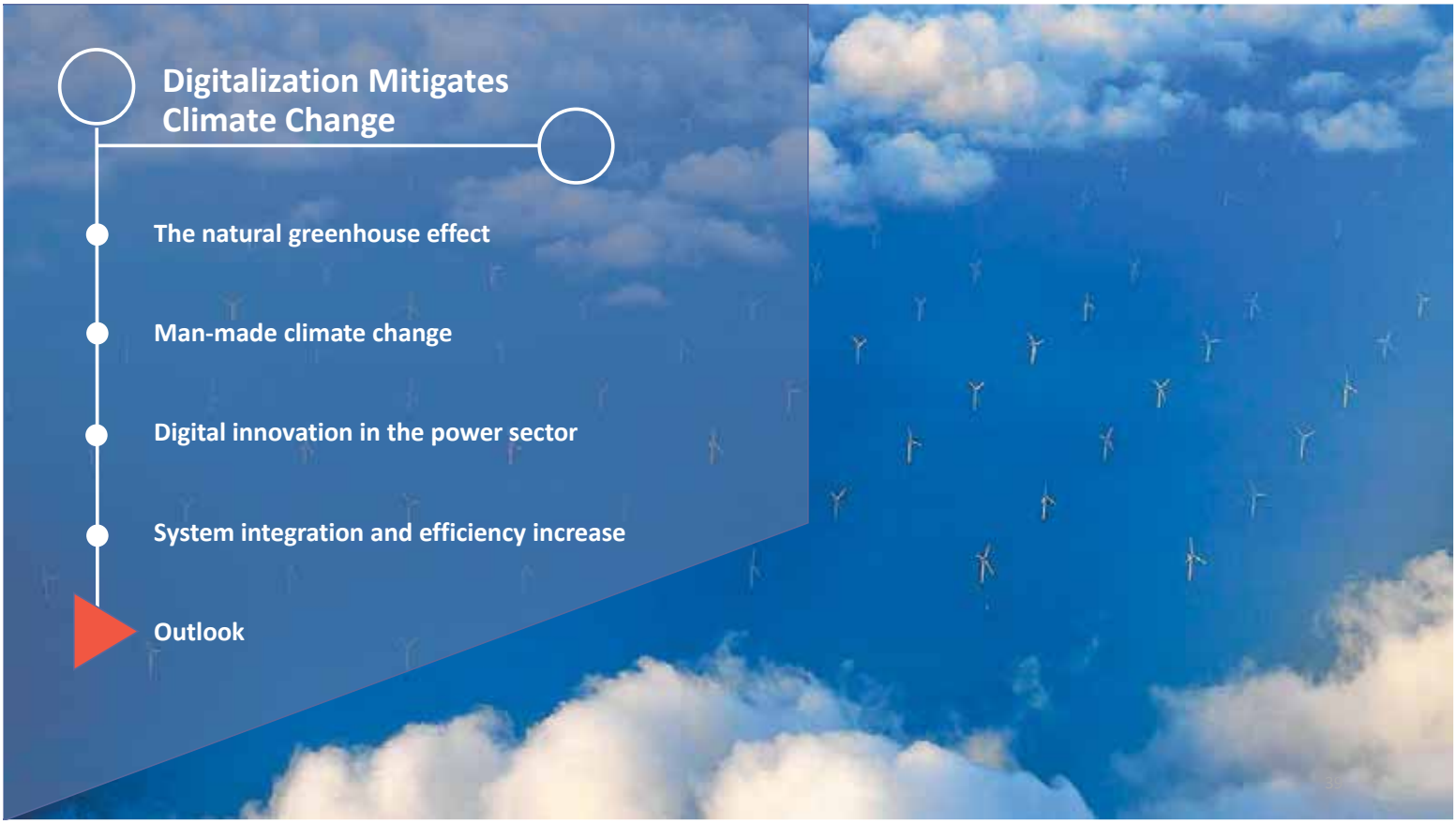
Global weighted average **Levelized Cost of Electricity** from newly commissioned, utility-scale renewable power generation technologies, 2010-2021

"Almost two-thirds – or 163 gigawatts of newly installed renewable power in 2021 had lower costs than the world's cheapest coal-fired options in the G20, confirming the critical role of cost competitive renewables in addressing today's energy and climate crises. Renewable energy provides the most compelling pathway to the decarbonization of the global future energy system and the achievement of the 1.5°C target."

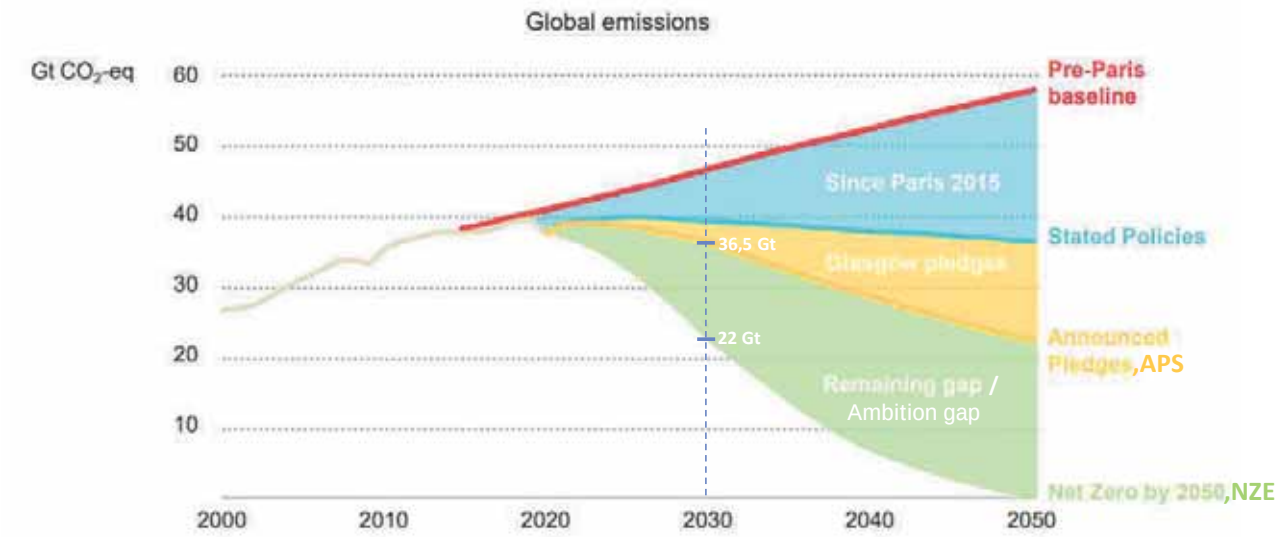
(IRENA Power Generation Costs 2021)



IRENA Renewable Cost Database

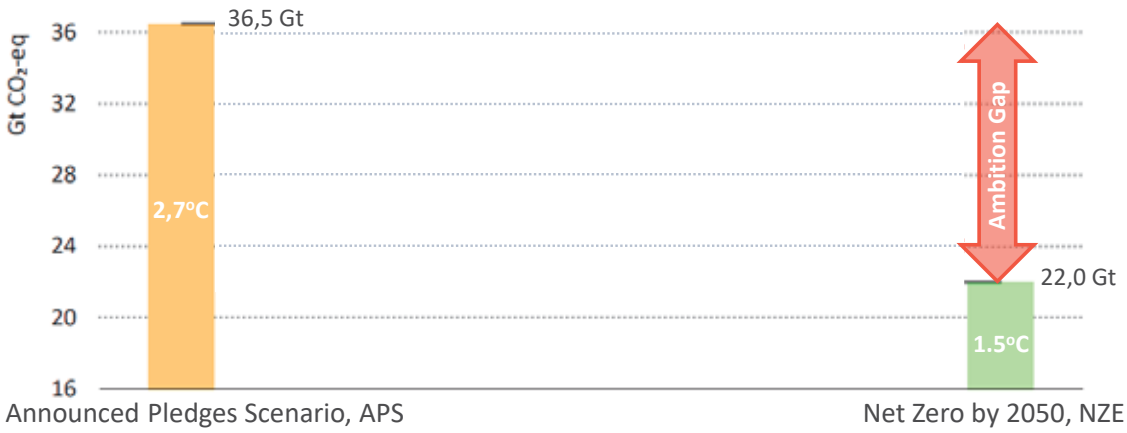


A large ambition gap remains in 2030 and in 2050

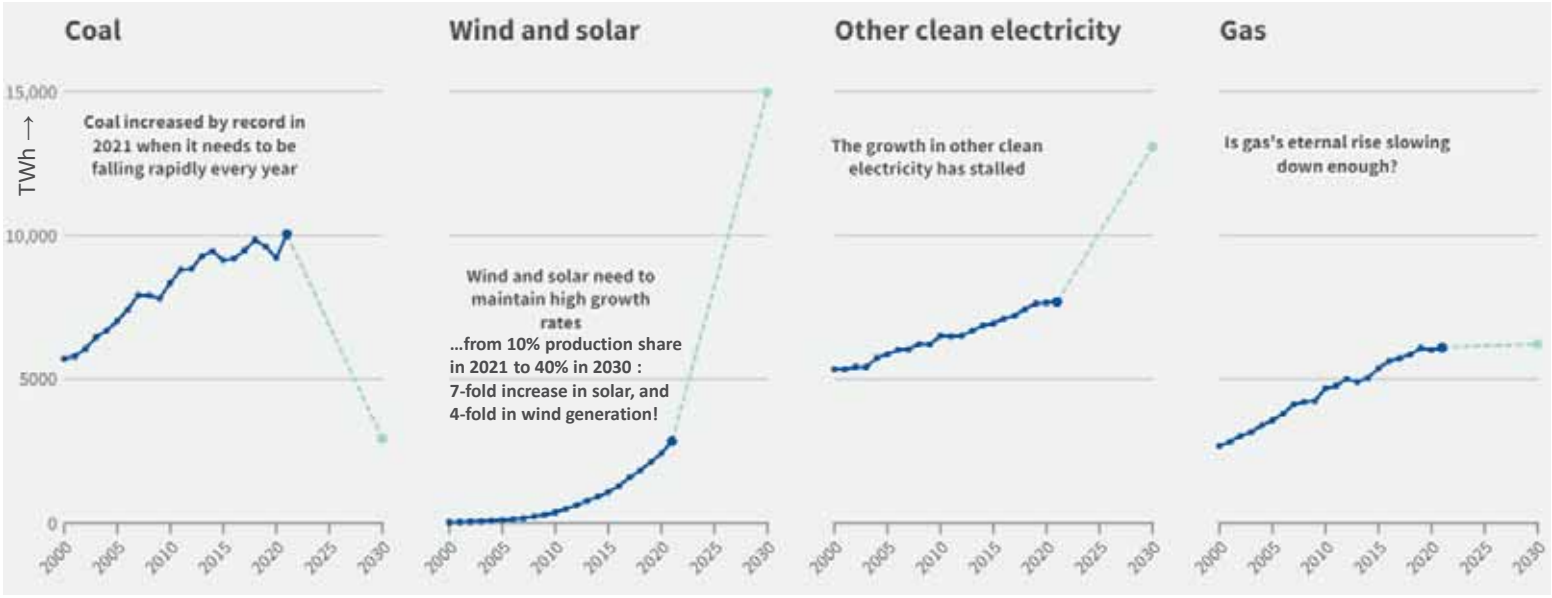


Adapted: IEA WEO2021_Launch_Presentation

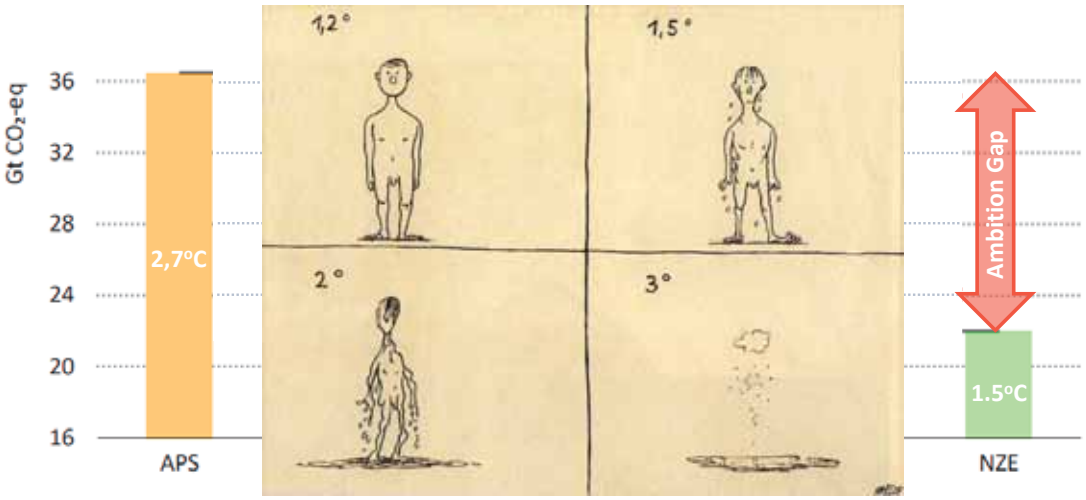
Resilience and New Efforts are Needed to Close the 2030 Ambition Gap Between APS and NZE



What needs to happen to close the ambition gap in 2030 for global electricity generation?



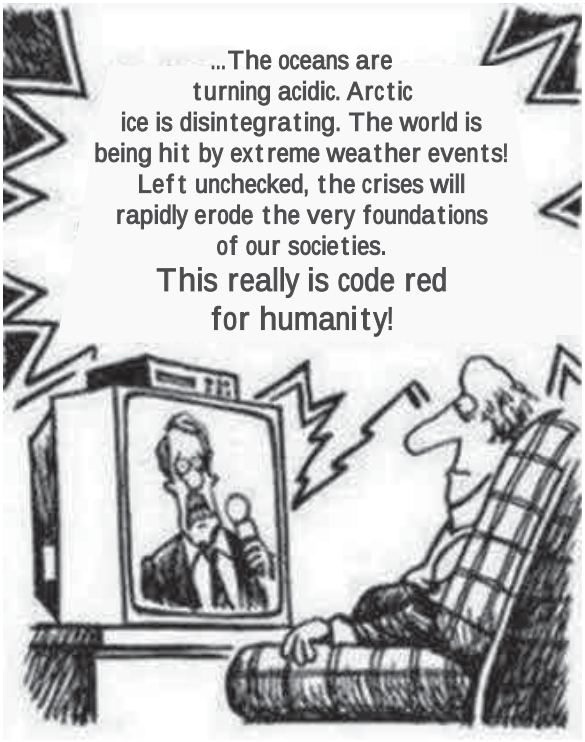
Resilience and New Efforts are Needed to Close the 2030 Ambition Gap Between APS and NZE

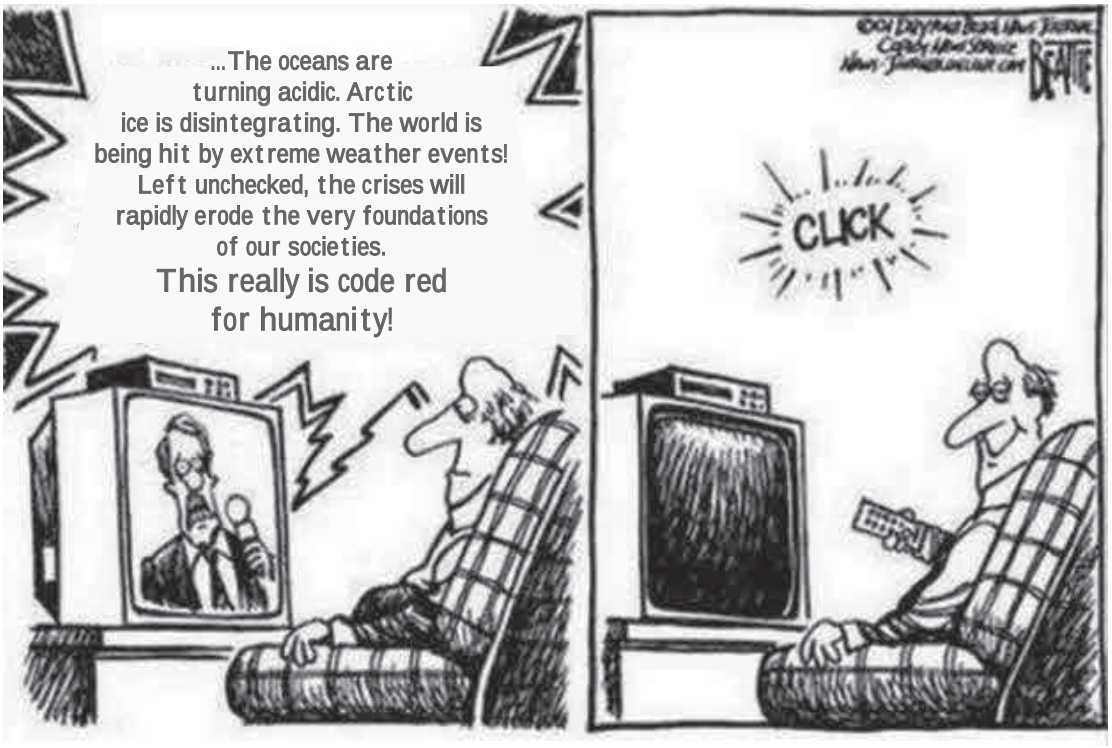


"The cumulative scientific evidence is unequivocal: climate change is a threat to human well-being and planetary health. Any further delay in concerted anticipatory global action on adaptation and mitigation will miss a brief and rapidly closing window of opportunity to secure a livable and sustainable future for all."

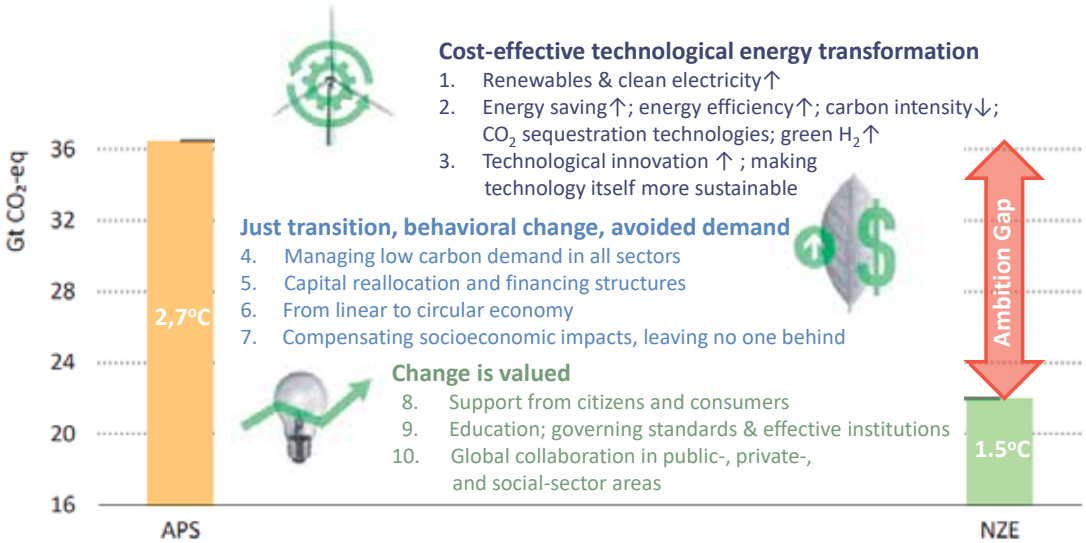
IPCC, 2nd part of 6th Assessment Report 2022

Intergovernmental Panel on Climate Change





Operational fields for mitigating the ambition gap challenge



Digitalization enables the technological energy transformation -
its role in the domain of socio-economic action appears less accentuated

Adapted: Deloitte: Climate & Digitization/The-turning-point-a-new-economic-climate-in-the-united-states-january-2022.pdf adapted: McKinsey Solving the net-zero equation: Nine requirements for a more orderly transition

Supporting energy transition and climate change is a matter of mindset and requires action…

Policy :

- The gap between climate pledges and implementation continues to widen, it is essential to accelerate the transition
- Strike the right balance between energy affordability, security, and sustainability.
- Protect vulnerable populations and businesses against the impact of future high energy prices with robust and well-targeted measures
- Supercharge the transition by increasing clean energy investments and transforming consumers' energy consumption habits
- There is a 12 trillion annual revenues market*) as the Net Zero transition advances…

*) McKinsey:Playing-offense-to-create-value-in-the-net-zero-transiton

Giant windmills near America's Interstate 10 in Palm Springs, California. Photo: Getty Images

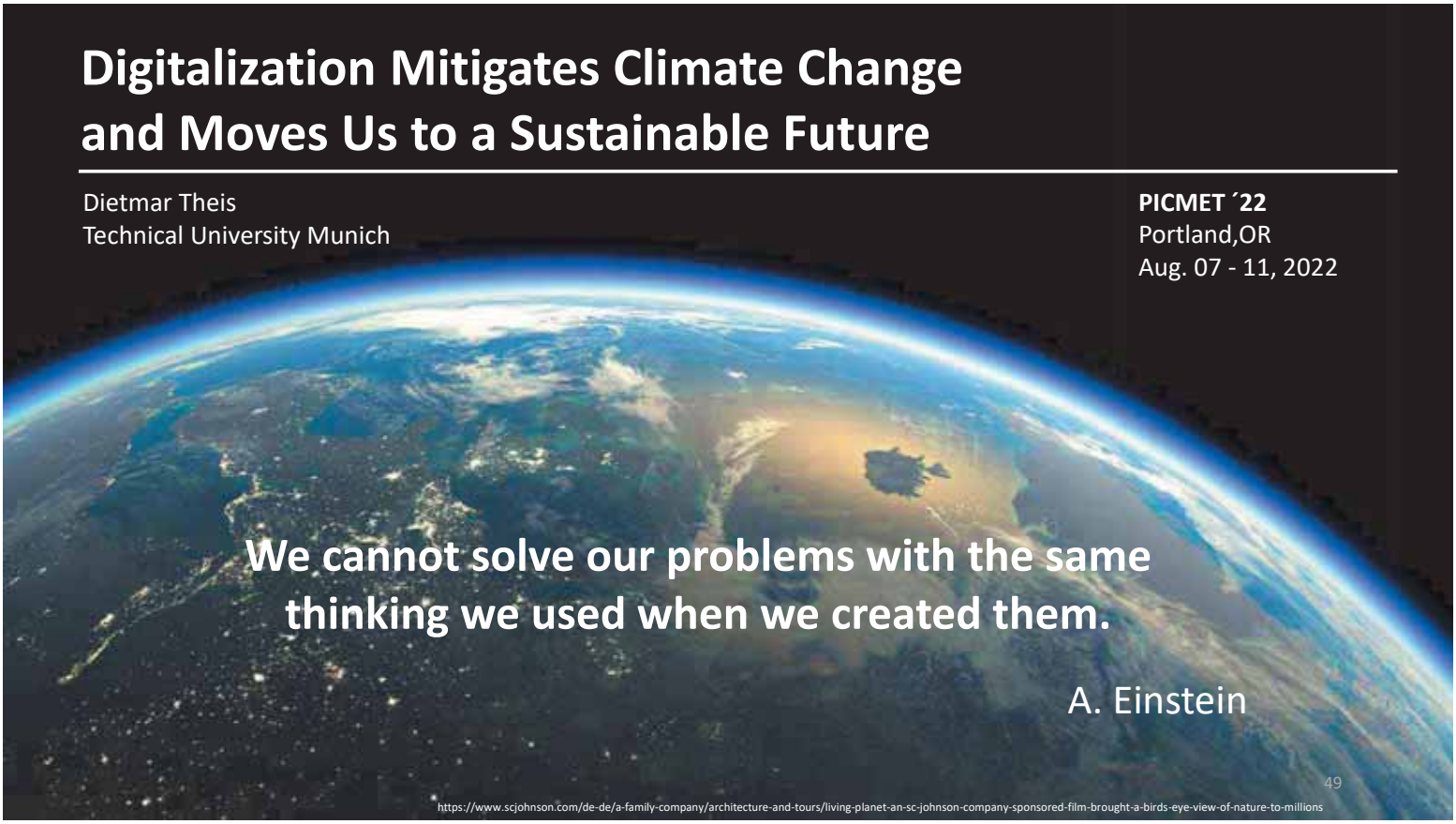
… therefore, it is not the proper time for neglect, phlegm, and hiding the head in the sand!

https://www.courtneyguestkim.com/tag/bury-head-in-the-sand/

Digitalization Mitigates Climate Change and Moves Us to a Sustainable Future

Dietmar Theis
Technical University Munich

PICMET ´22
Portland,OR
Aug. 07 - 11, 2022



We cannot solve our problems with the same thinking we used when we created them.

A. Einstein

https://www.scjohnson.com/de-de/a-family-company/architecture-and-tours/living-planet-an-sc-johnson-company-sponsored-film-brought-a-birds-eye-view-of-nature-to-millions

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