ENERGY

DIGITALIZATION AND FUTURE OF WIND ENERGY

Energy Transition Outlook 2019

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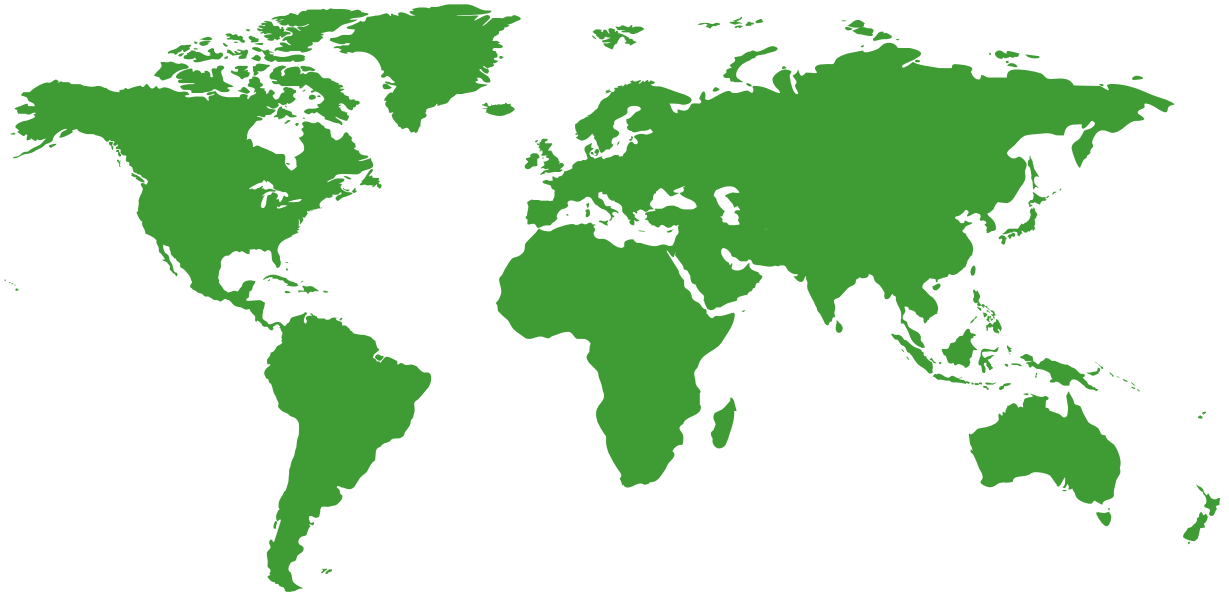
Team Leader & Independent Consultant

DNV GL: a quality assurance and risk management company



MARITIME

OIL & GAS

ENERGY

BUSINESS ASSURANCE

DIGITAL SOLUTIONS

150+ years

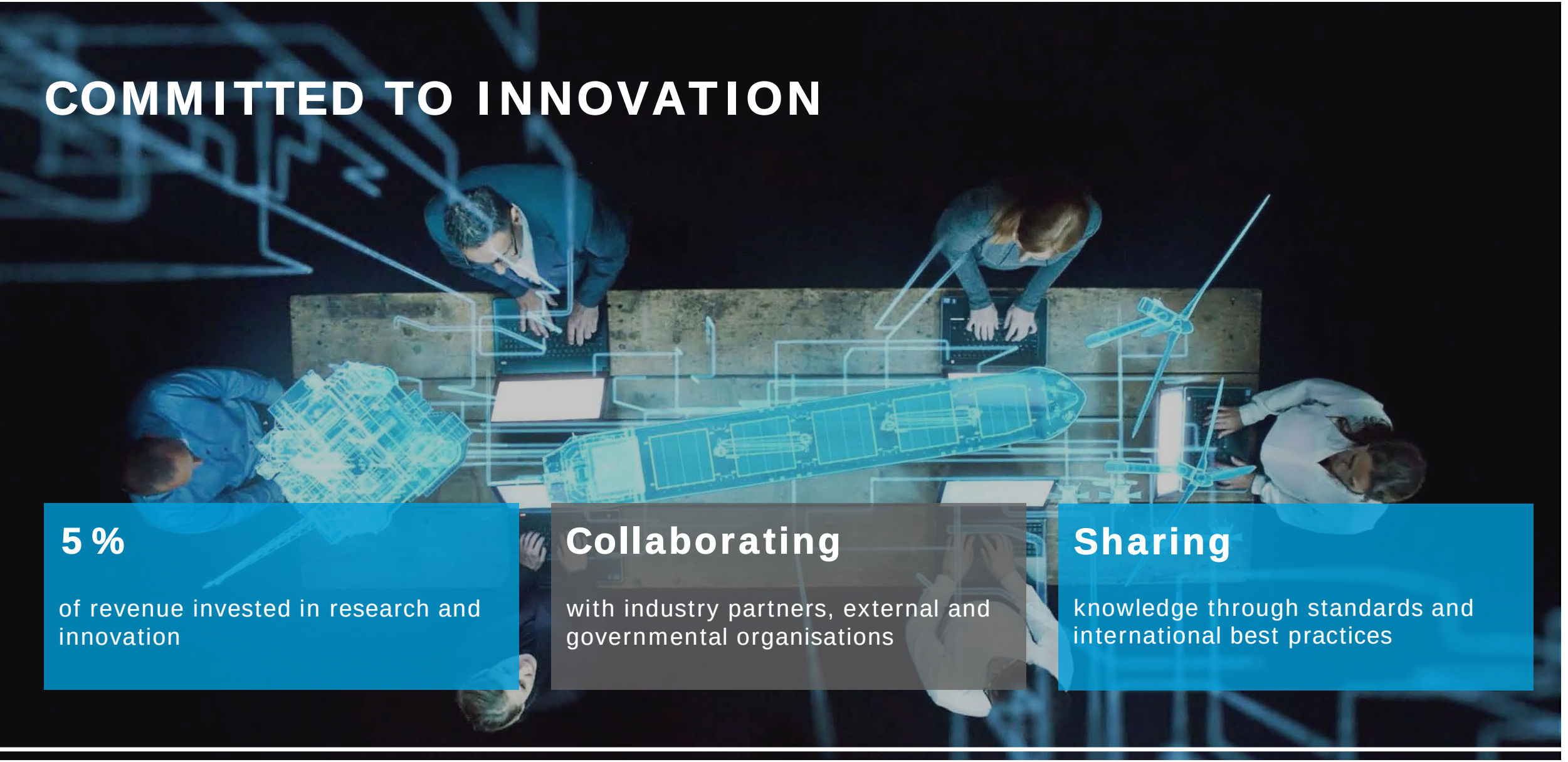
100+ countries

100,000 customers

12,500 employees

5 % of revenue spent on R&D

COMMITTED TO INNOVATION



5 %

of revenue invested in research and innovation

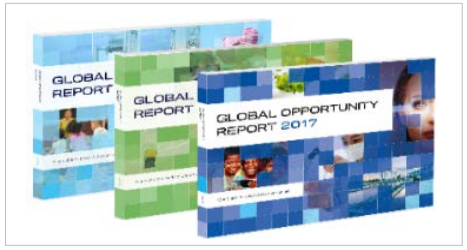
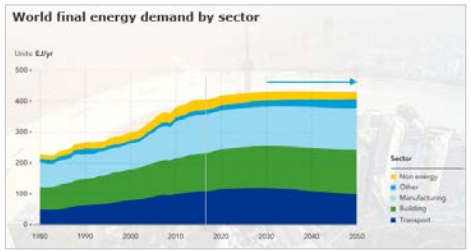
Collaborating

with industry partners, external and governmental organisations

Sharing

knowledge through standards and international best practices

Our Outlook publications

2017	2020	2025	2030	2050
Industry Outlook The oil & gas industry benchmark report - Industry sentiment - Confidence - Priorities	**Global Opportunity Report** The solutions for World Economic Forum's Global Risk Report	**Technology Outlook** The technology landscape of the next decade - Energy - Health - Maritime	**Future of Spaceship Earth** The stress test for our planet and the evaluation of UN Sustainable Development Goals - Leader companies	**Energy Transition Outlook** The independent forecast of energy demand and supply - 10 regions
				

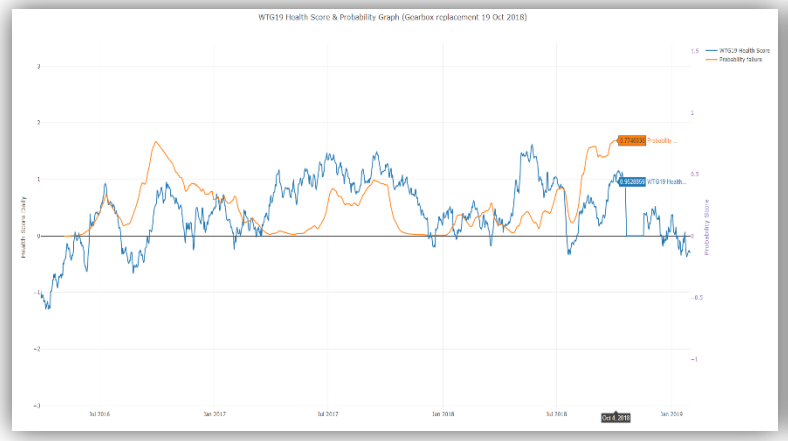
Our Digital Solutions / Tools

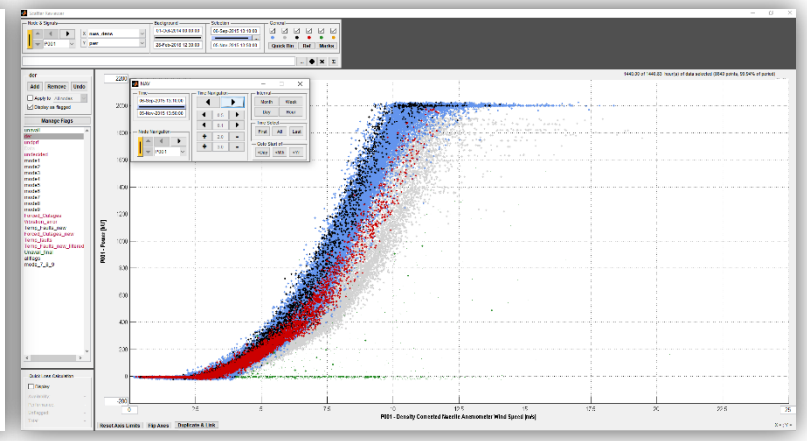
Commercial in confidence

Tools

Commercial asset management and analytics platform

Internal analytical tools





Commercial in confidence

Global Operations and Analytics Centre (GOAC)

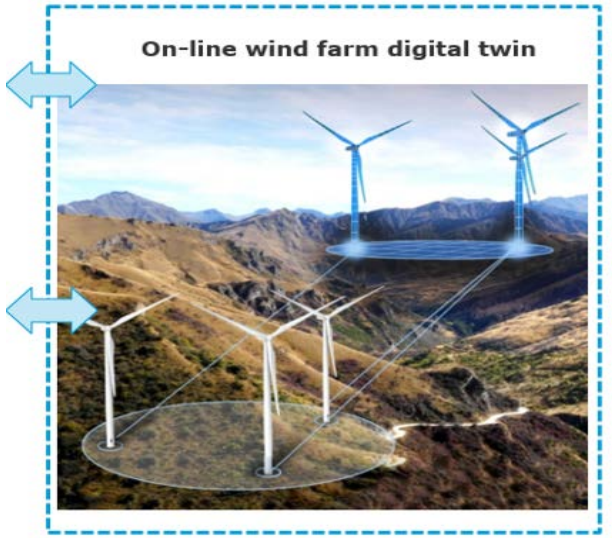
- The Global Operations and Analytics Centre is a new smarter monitoring/smarter operations service planned that can monitor and analyse renewable assets (solar, wind or storage) 24x7, anywhere in the world.

Outputs;
- Daily/weekly/monthly full status reports
- Availability and performance warranty calculations
- Performance analysis and validation
- Production loss accounting
- Ad hoc fault analysis

Deep domain expertise in renewables

24x7 remote asset monitoring

Global Operations & Analytics Centre



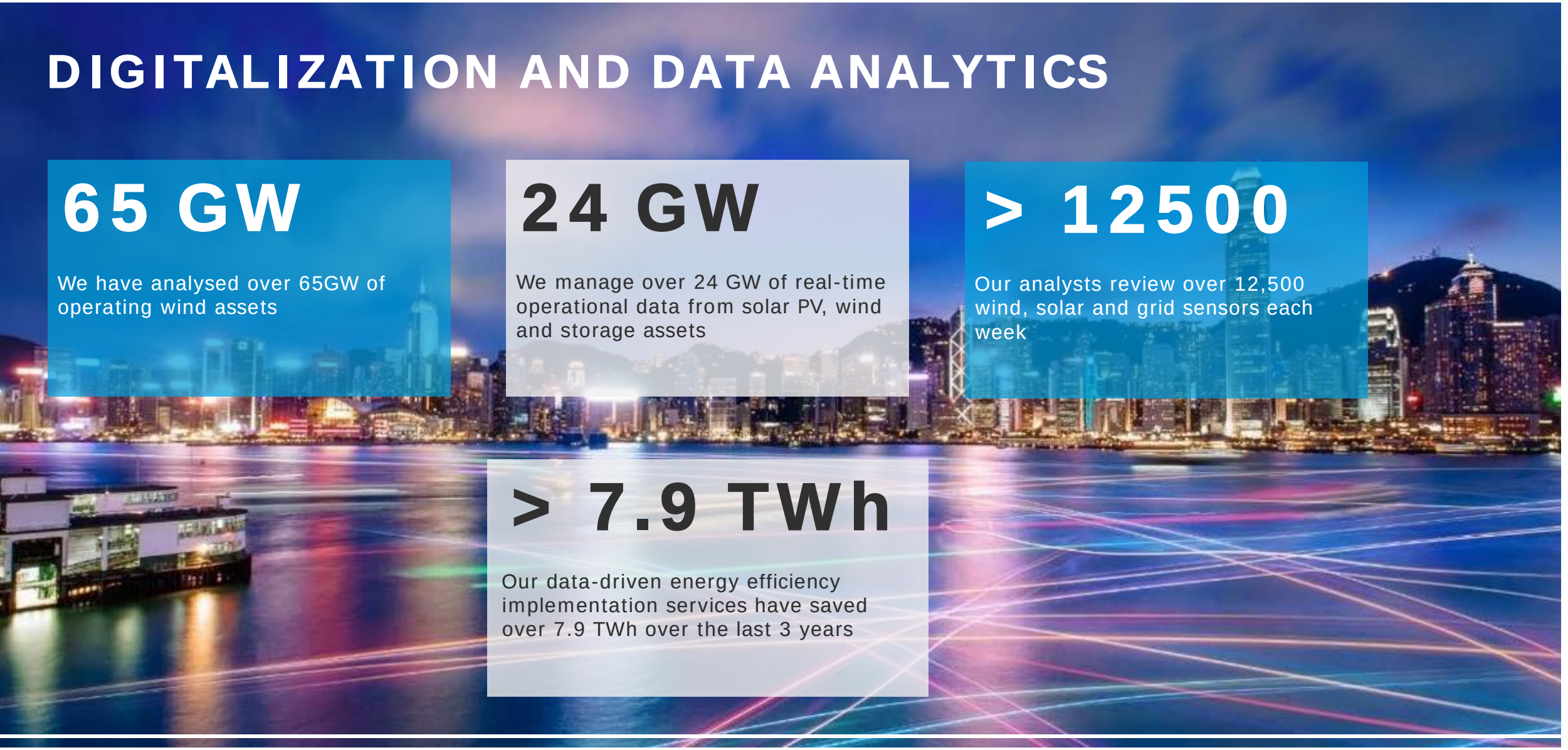
Cutting edge analytics services including big data analytics, machine learning

DNV GL Asset Operations Experience

Over 20 years of operational experience:

- Operational analysis for > 65 GW
- Forecasting for > 40 GW
- Inspections for > 700 turbines per year
- SCADA systems in wind installed on over 8 GW
- DNV GL since 2003 has strong Solar portfolio of 25 GW spread across more than 6,000 projects globally

DIGITALIZATION AND DATA ANALYTICS



65 GW

We have analysed over 65GW of operating wind assets

24 GW

We manage over 24 GW of real-time operational data from solar PV, wind and storage assets

> 12500

Our analysts review over 12,500 wind, solar and grid sensors each week

> 7.9 TWh

Our data-driven energy efficiency implementation services have saved over 7.9 TWh over the last 3 years

WHAT IS DIGITALIZATION?

DIGITIZATION

Making things digital

DIGITALIZATION

Business opportunities created by digitization

DIGITAL TRANSFORMATION

Changing business models with digitalization

DIGITAL TECHNOLOGY

COMPUTERS

Large and small

Distributed

Cloud

Edge

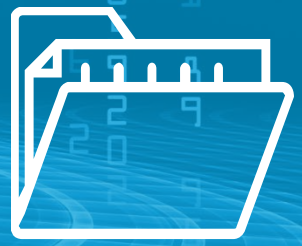
CONNECTIVITY

Internet

Mobile

5G

SENSORS & DATA



Proliferation of data

Decreasing cost of sensors

IoT

SOFTWARE

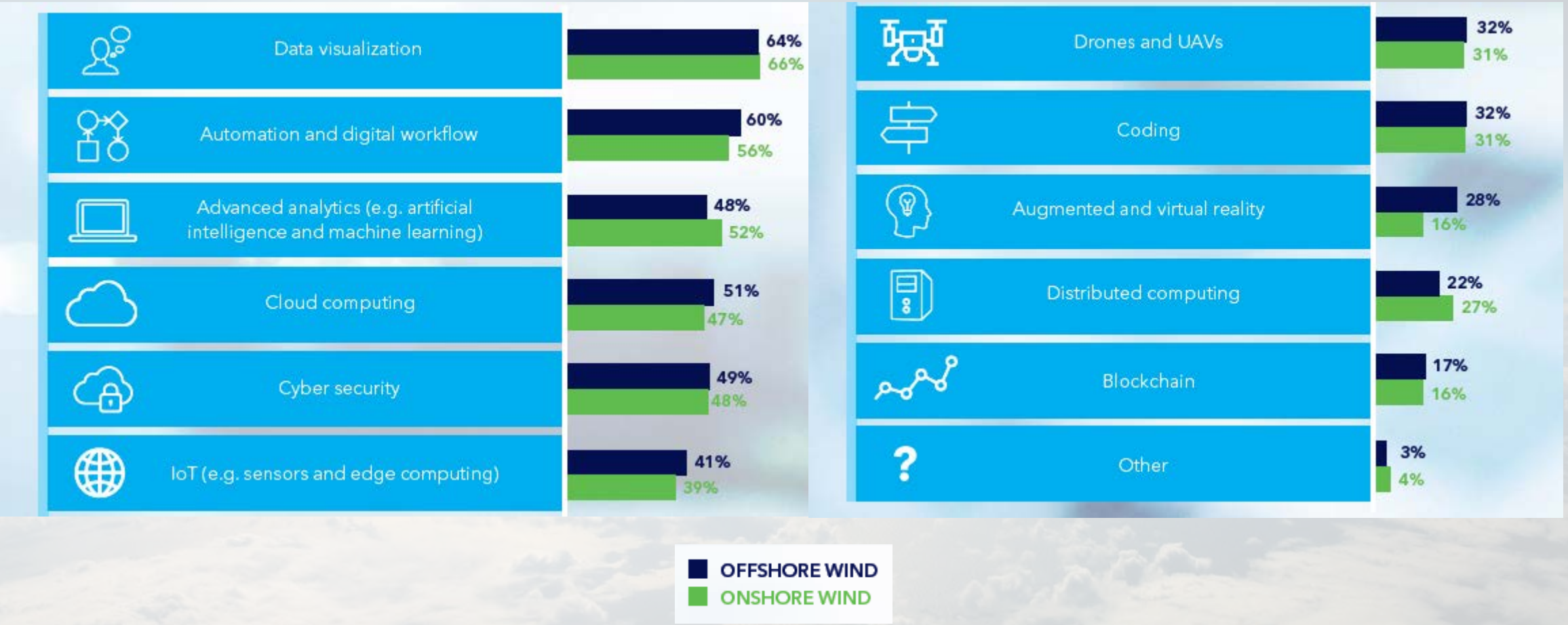
Machine learning

Big data

Blockchain

Some technology is over-hyped

Which of the following digital technologies are impacting the wind industry today?



Main ETO report messages

Overarching message:

We are facing a rapid energy transition, but not fast enough to meet the COP 21 1.5°C or 2°C goals. Technology is not the problem, policy is!!!

Key messages:

1. Our model indicates global warming at 2.4 degrees above pre-industrial levels by the end of the century
2. Global emissions will peak in 2025
3. Emissions by 2050 will still be more than half of present levels
4. The share of electricity in the final demand mix will be more than double from today's level and PV and wind will represent almost 2/3 of that electricity
5. An electric engine is 3-4 times more efficient than the combustion engine it replaces by 2030
6. Half of light vehicles sold worldwide will be EVs by 2032
7. Gas overtakes oil as the largest energy source in 2026
8. Cheaper and better technologies enable an affordable energy transition

Wind – Outlook to 2050

- Wind will grow rapidly to represent a 29% share of world electricity generation and around 16% of world energy supply.
- Onshore wind dominates this growth but offshore wind's contribution will also increase, reaching about 20% of total wind production.
- This growth will change wind's position as a "new conventional" rather than a challenger technology with relatively higher risk.
- Remaining competitive through continued digitalization will be instrumental in enabling wind industry's ambitions in the future.

We asked the power and renewables industry ‘why digitalization?’

QUANTITATIVE

1,919

respondents from across the power and renewables industry

QUALITATIVE

5

in depth qualitative interviews

GOLDWIND

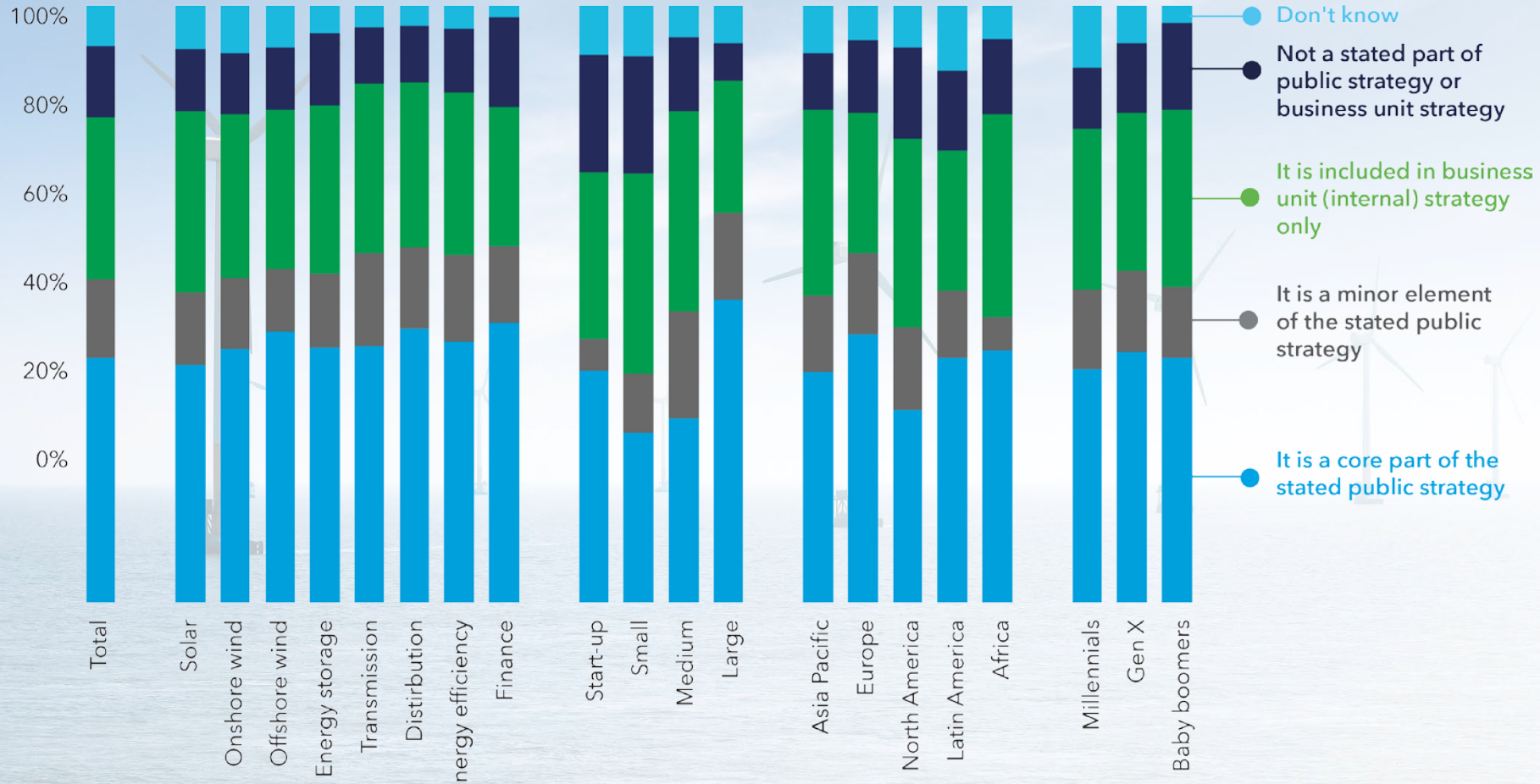
LO3ENERGY

MACQUARIE

PSEG

res power for good

Two Fifths Place Digitalization as a Core Public Strategy



87 %

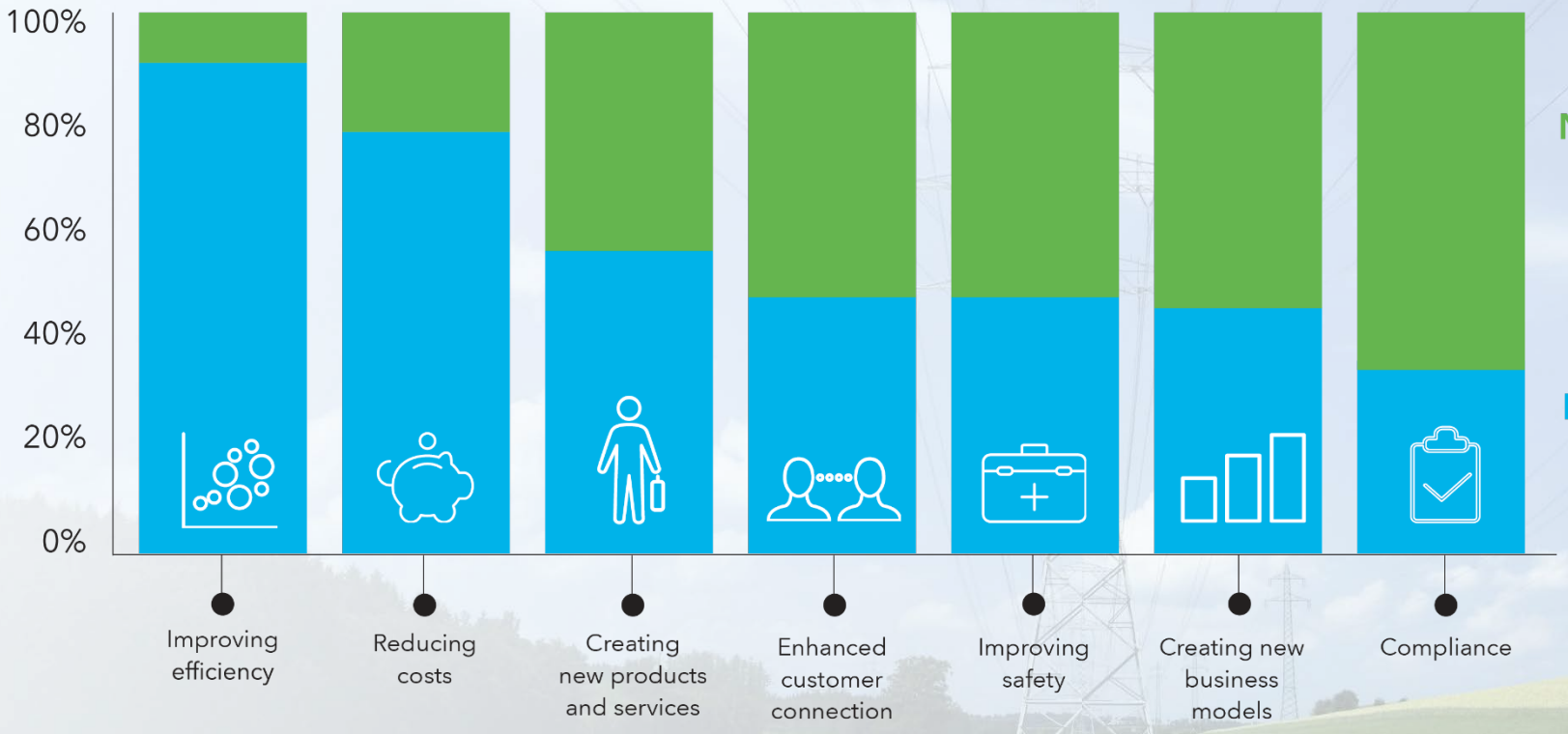
have a digital strategy

41 %

digitalization is core to their public strategy

Improving efficiency is the main goal of digitalization

What are your organization's main goals regarding their digitalization strategy? Ranked in order of priority

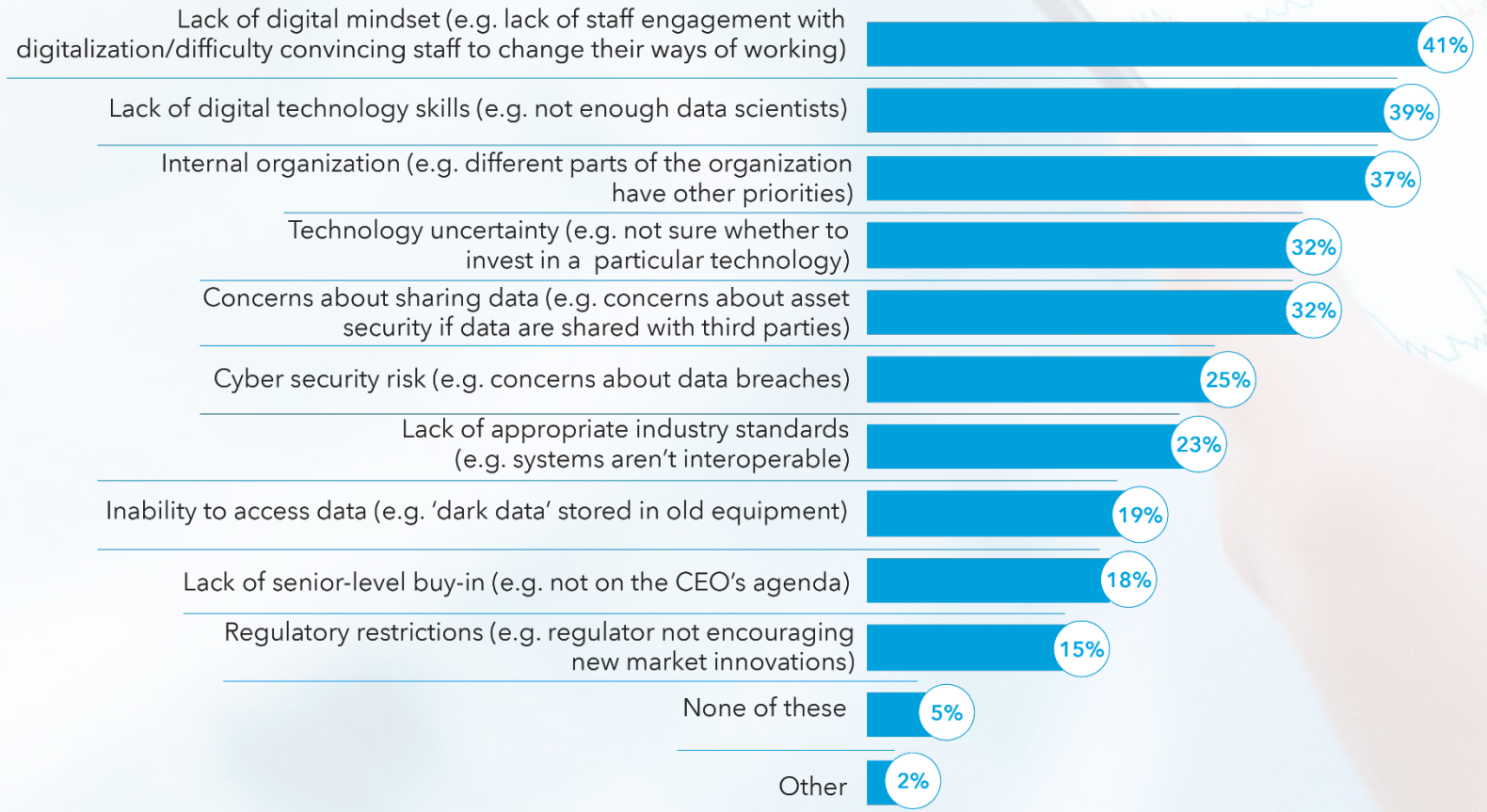


89 %

improving efficiency is the main goal for digitalization

Lack of digital mindset and skills are significant barriers

Which of the following do you consider to be the main barriers of digitalization for your organization?
% choosing any in their top 3



41 %

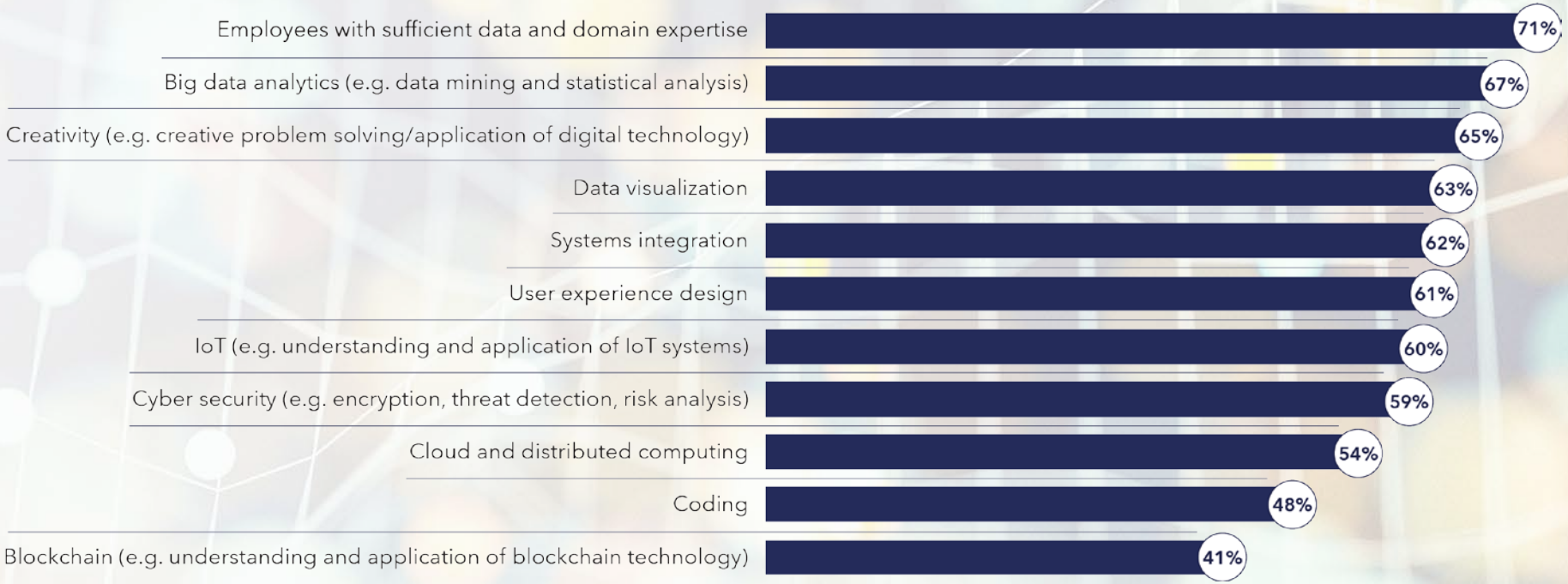
lack of digital mind set

39 %

lack of digital skills

Combined digital and domain knowledge is in high demand

Which of the following digital skillsets does your organization have among its workforce and which does it need? % who need the following skills



71%

need employees with combined data and domain knowledge

41%

data science is a top skill for the future energy workforce

IT'S TIME TO MOVE BEYOND THE HYPE

87%

have a digital strategy

Digitalization is clearly important for the power and renewables industry

89%

improving efficiency is the main goal for digitalization

Digitalization is improving efficiency, reducing costs, enhancing customer satisfaction

41%

lack of digital mind set

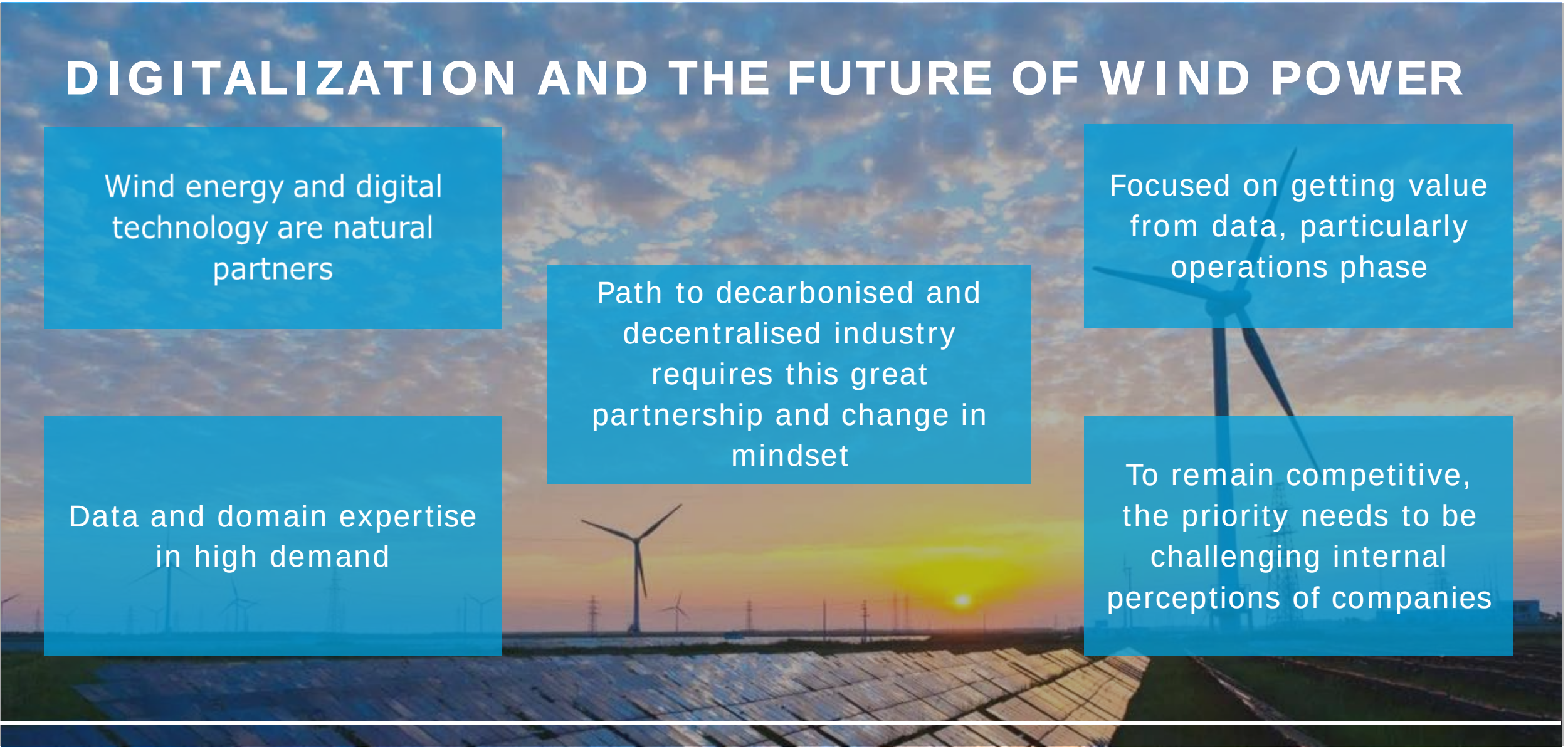
Digitalization requires digital technology skills, but human factors are crucial

71%

need employees with combined data and domain knowledge

Digitalization needs to be connected to engineering to make an impact

DIGITALIZATION AND THE FUTURE OF WIND POWER



Wind energy and digital technology are natural partners

Path to decarbonised and decentralised industry requires this great partnership and change in mindset

Focused on getting value from data, particularly operations phase

Data and domain expertise in high demand

To remain competitive, the priority needs to be challenging internal perceptions of companies


Thank you.
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www.dnvgl.com/futureofenergy