

GE Renewable Energy Onshore Wind

2017 NZWEA

Chris Holsonback, Product Strategy



Imagination at work.

24 Internet-connected GE 2.85-103 wind turbines
Lake Huron, Ontario, Canada

Renewables are Big Business...

Cheaper coal and cheaper gas will not derail the transformation and decarbonisation of the world's power systems. From today until 2040, \$11.4tn will be invested in power generation. Of that, \$2.1tn will be spent on fossil fuels. But an astonishing \$7.8tn will be invested in renewable energy.



US\$7.8tr
Renewable

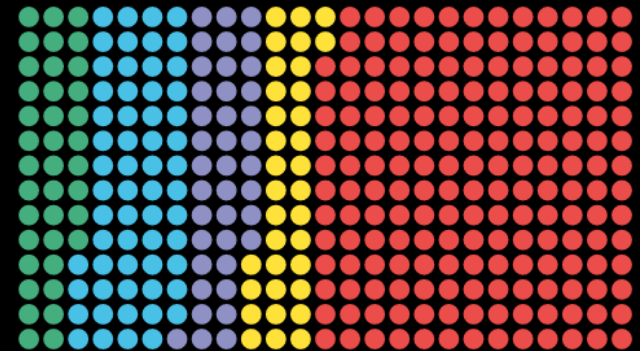


US\$3.2tr
Fossil fuels & nuclear

Total investment in power generation to 2040
Source: bnef.com

Europe AMER MEA RoW APAC

The bulk of the \$11.4 trillion will be invested in Asia-Pacific which will add as much capacity in the next 25 years as the rest of the world combined.



Cumulative capacity additions by region
Source: bnef.com

US\$7.8 trillion investment in RE expected between now and 2040

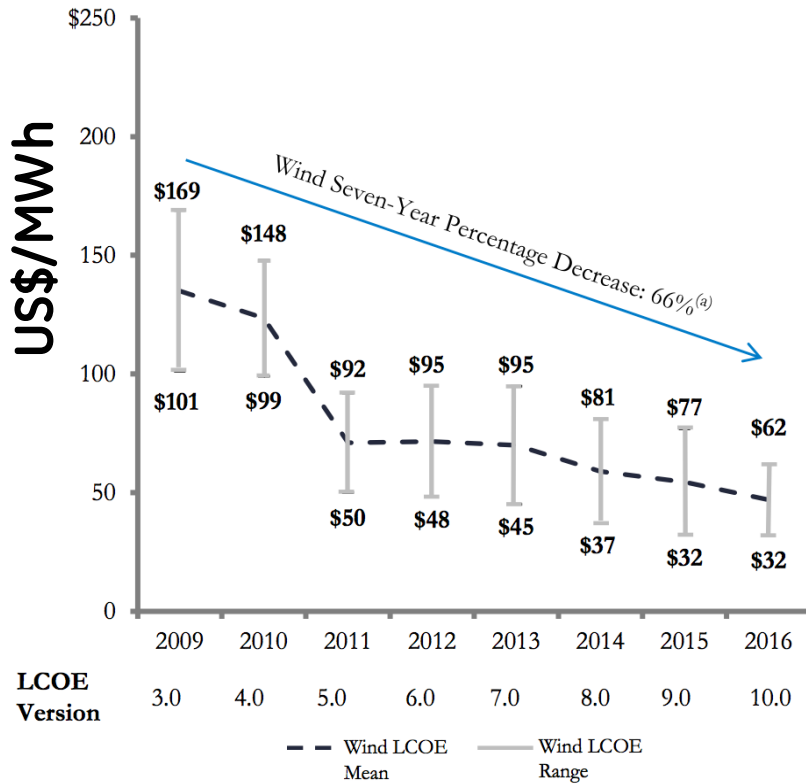


Source: Bloomberg New Energy Outlook 2016

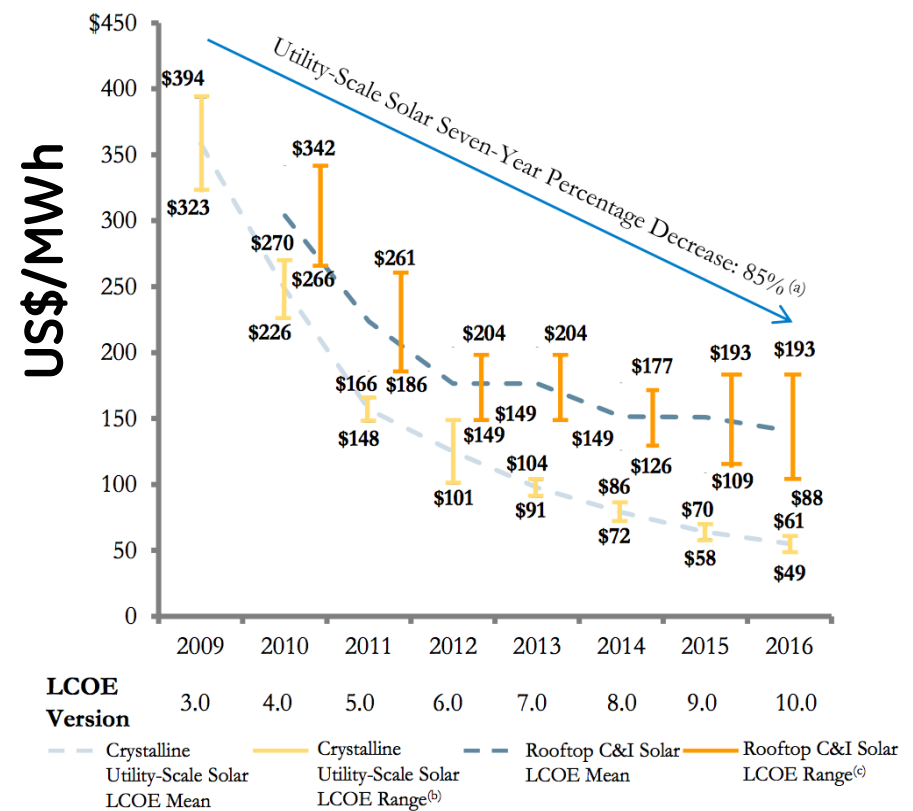
<https://www.bnef.com/dataview/new-energy-outlook-2016/index.html#section-0>

...At the same time costs are falling

Wind Levelized Cost of Energy (LCOE)



Solar PV Levelized Cost of Energy (LCOE)



New wind & solar are cheapest new-generation options



Source: LAZARD US-focused New Generation LCOE Analysis, v10.0 (2016)

<https://www.lazard.com/media/438038/levelized-cost-of-energy-v100.pdf>

Now the world is moving to auctions...

THE HINDU
BusinessLine

Wind power tariffs crash to ₹3.46/kWhr, set a new benchmark at auction

CHENNAI/NEW DELHI, FEB 24: Wind power prices have crashed to ₹3.46 a kWhr in the country's first ever auction of wind capacity. The least wind tariff today is ₹4.16 in Tamil Nadu, if one ignores the outlier ₹3.82 for some specific sites in Maharashtra.

This fall in wind tariffs mirrors a similar trend in solar tariffs witnessed earlier this month, when the prices fell to an unprecedented ₹3.29, averaged over 25 years.

 **ICIS**

Spain could hold 3GW clean power auction by end of April

03 April 2017 15:40 Source: ICIS

Spain could hold an auction of 3GW of new renewable capacity by the end of this month. However, the government is unlikely to meet its goal of 8.5GW of new renewable capacity by 2020 unless it ramps up the amount of capacity on offer in later auctions, according to a spokeswoman for the country's wind association AEE.

 **Energy Live News**

UK Government launches second green power auction

Apr 04, 2017 Priyanka Shrestha Markets & Finance, Policy & Legislation, Top Stories

Renewable energy developers have started competing for £290 million worth of contracts.

It is the second **Contracts for Difference (CfD)** auction, which supports renewable technologies and guarantees developers a certain price for the low carbon electricity they produce over 15 years.

It represents the first part of the government's commitment to provide up to £730 million of annual support for green power projects over the course of this Parliament.

WINDPOWER
MONTHLY

TURKEY

Partnership prepares as Turkey debuts new auction system

22 March 2017 by Heather O'Brian, Be the first to comment

TURKEY: A consortium comprising GE and local power producers has signed a memorandum of understanding (MoU) ahead of the launch of a new auction system.

We must position to beat grid parity prices ... subsidy free



Source: various, as shown

GE Renewable Energy

US\$10B Revenue, 13k Employees, 55 Countries



Jérôme Péresse, CEO
Paris, France



Onshore Wind

Delivering low cost energy solutions with differentiated products & services

2 & 3MW wind turbine platforms
Optimizing hardware to get the most out of the wind resource

Wind Services

Focus on customer outcomes, realizing
↑ AEP & profit over the lifetime of the fleet

Digital Wind Farm

A farm level solution- dynamic, connected
& adaptable wind energy ecosystem



Offshore Wind

Setting the benchmark for the marine energies industry

Fixed bottom offshore wind turbines:
Haliade* 150-6MW

Floating offshore wind turbines
Haliade* 150-6MW

Wind services
(preventive and corrective maintenance)

Tidal turbines

Oceade* tidal turbines platform,
including Oceade* 18 - 1.4MW, electrical
subsea hub



Hydro

Collaborating with customers as the #1 player in the hydropower market

Hydropower solutions, products and services for:

- Low head hydropower plants
- Medium head hydropower plants
- High head hydropower plants
- Pumped storage hydropower plants
- Small hydropower plants
- Concentrated solar power plants
- Geothermal power plants
- Biomass power plants

Powering our customers with the world's largest clean energy footprint






GE Onshore Wind: A Global Presence



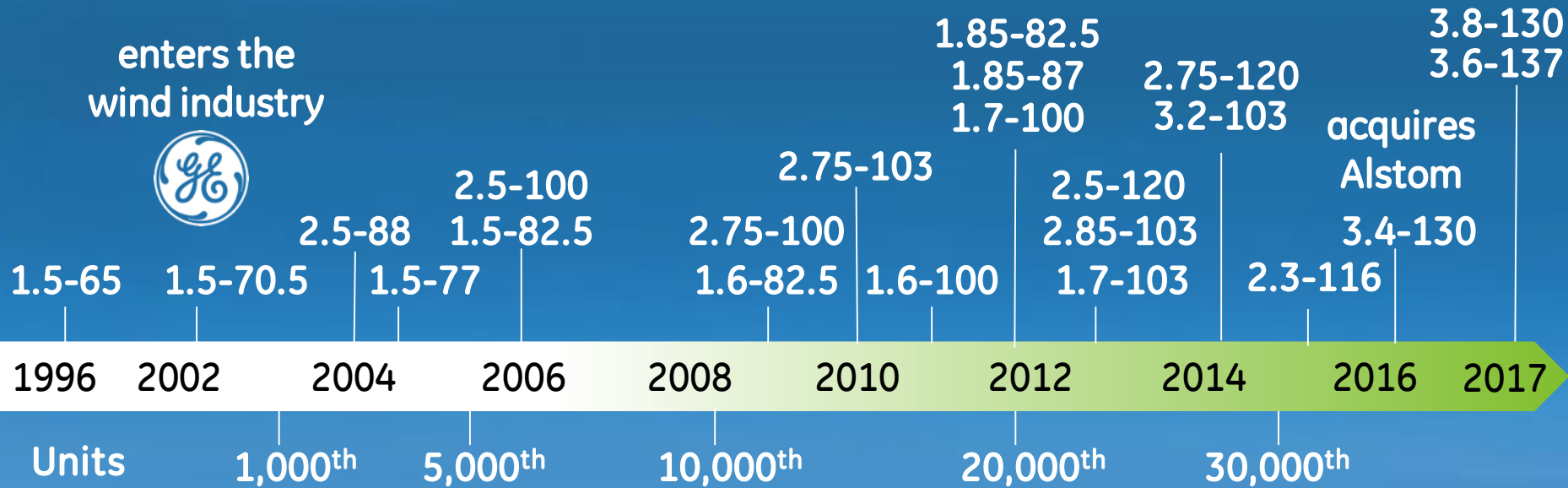
Pete McCabe, VP & CEO
Chicago, IL USA



-  Areas where Onshore Wind is commercially active
-  Onshore Wind Energy Centers
-  GE Global Research locations



Evolution of the GE Portfolio



Nearing 40,000 deployed units and 20 years in wind



3 MW Platform: Reliable by Design

Hub

- High stiffness and low deformation
- Rear-facing hatch for easy access
- Integrated GE pitch system with patented load mitigating controls

Generator

- DFIG for excellent overall efficiency
- Dual-voltage (6kV/690V) to reduce losses
- Partial power GE converter

Blades

- Glass fiber epoxy/polyester
- Advanced aero design
- VGs, low noise trailing edge
- Full scale blade test to validate design

Bedplate

- Integrated rotor lock
- Double main bearings to dramatically reduce bending loads

Gearbox

- Designed in-house for reliability
- Manufactured by 1st Tier suppliers
- HALT test to validate design assumptions



3.8-130

Powerful & efficient ... for medium to high wind speeds

What's
NEW?

Gearbox + Strengthened main shaft + Advanced aero blade + Electrical upgrades
2.75-120 > 3.2-130 > 3.4-130 > **3.8-130**

3.8-130

IEC ed3 Wind Class

2B, 8.5 m/s

Gross AEP

~17.2 GWh

Gross CF

51%

Hub Height

85, 95, 110, 115 m tube

Noise

107 dBA

Technology

- Model based controls
- Low noise trailing edge
- Energy storage enabled
- Weak grid support
- Hot/Cold weather extreme (optional)



3.6-137

A powerful turbine for low wind environments

What's
NEW?

Gearbox +

Electrical
upgrades

+

Advanced
aero blade

2.75-120 >

3.2-130 >

> 3.6-137

3.6-137

IEC ed3 Wind Class

3B, 7.5 m/s

Gross AEP

~14.9 GWh

Gross CF

47%

Hub Height

91.5, 111.5, 131.5 m tube

Noise

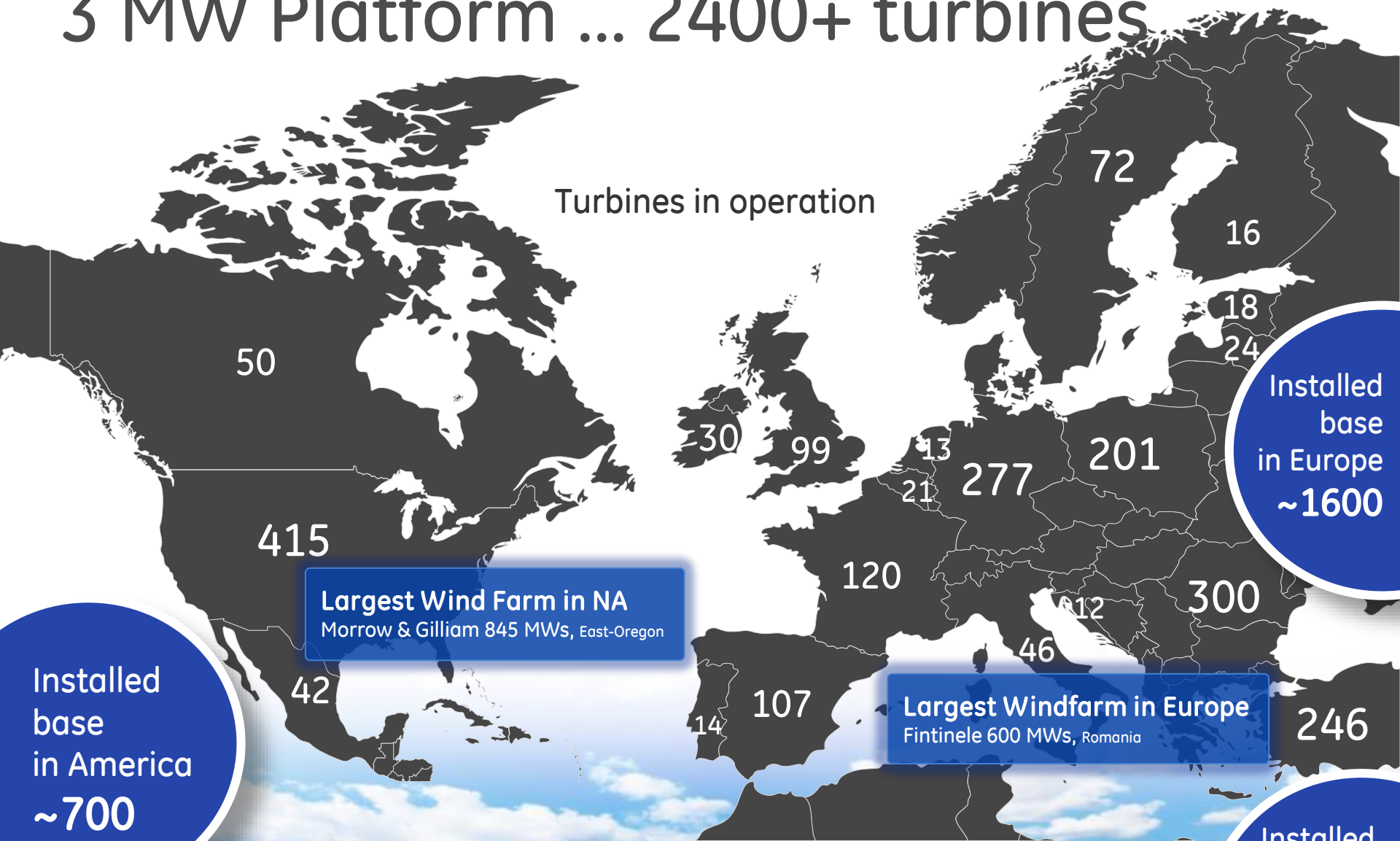
106 dBA

Technology

- Model based controls
- Low noise trailing edge
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- Weak grid support
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3 MW Platform ... 2400+ turbines



Installed base in America ~700

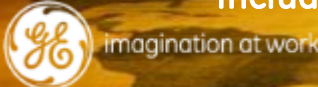
Largest Wind Farm in NA
Morrow & Gilliam 845 MWS, East-Oregon

Largest Windfarm in Europe
Fintinele 600 MWS, Romania

Installed base in Europe ~1600

Installed base in APAC ~100

Including ~380 Units from former Alstom ECO 3MW platform



Flexible Service Offerings

Selecting the customized solution for your fleet

Scope

Choose your risk level...
from maintenance support to optimized
operations and everything in between.
GE manages your fleet risk.

Term

From COD to end of life, choose the
contract length that best fits your needs.

Pricing

From fixed fee to variable fee to revenue
sharing, customized pricing structures
align to your outcomes.



Contractual Service Offerings

Selecting the customized solution for your fleet





GE develops **a tailored solution** with you that supports your strategy.

ATTRIBUTE	PRODUCT FEATURE	EXPANDED SERVICE ESA	FULL SERVICE FSA	OPERATIONAL SERVICE OSA
Enhanced Performance	Wind PowerUp* Services Platform			
Operations Solutions	Asset Management • Operating plan, NERC support			
	Park Management • Site operations, eBOP, BOP			
Unplanned Maintenance	Customizable unplanned coverage • Full scope • Major components • Minor components			
	Availability guarantee			
	Manual resets and troubleshooting			
Planned Maintenance	Parts management			
	Preventive maintenance			
	Routine maintenance			
Monitoring & Diagnostics	Remote monitoring and resets			
	PulsePOINT* Services			<i>Lite</i>
	Data analytics and reporting			
	Technical advisory support			



Enhance and super-charge your wind farm using digital applications



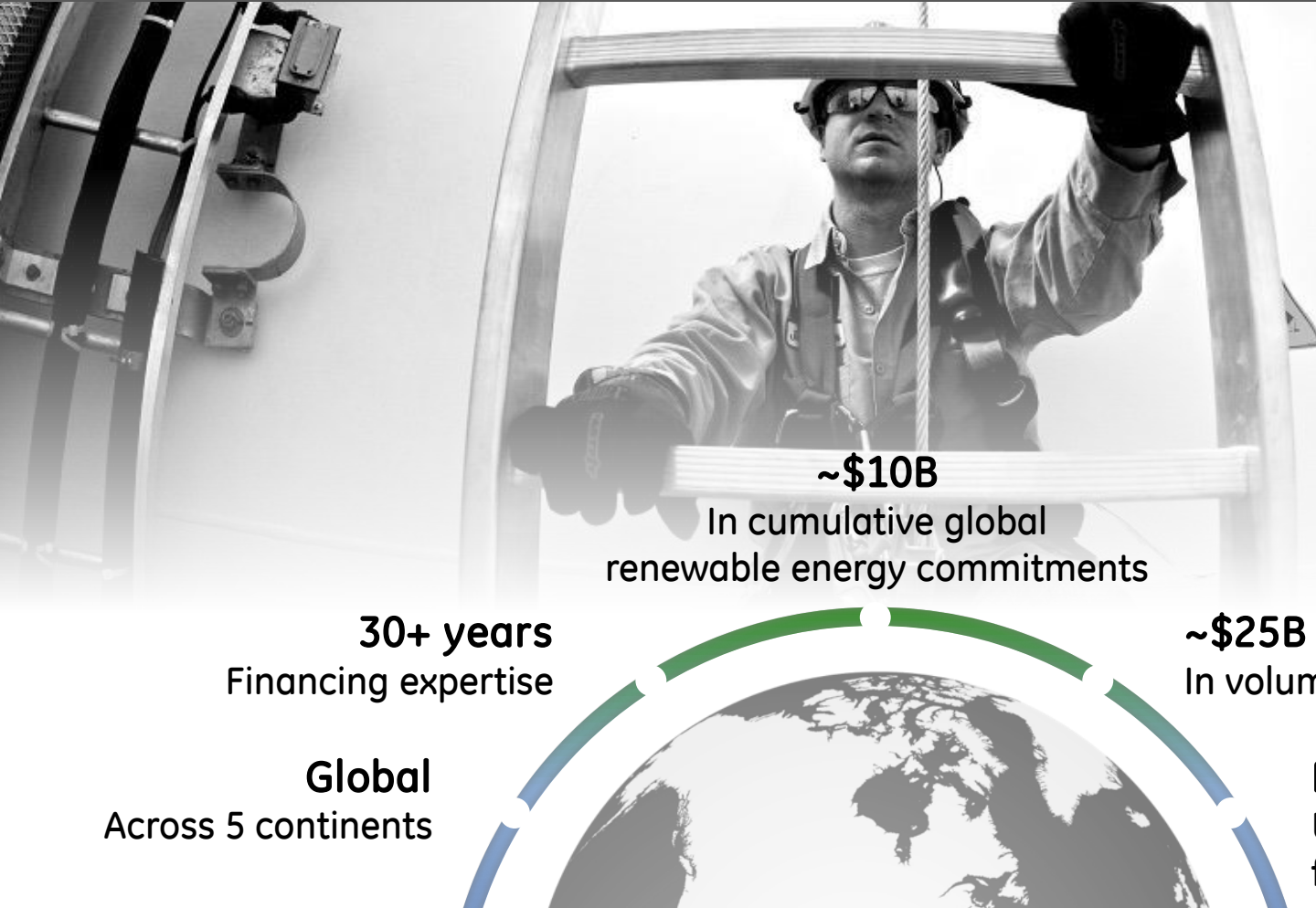
Category	MODULES				OUTCOMES
 Business Optimization	Market Intelligence & Forecasting	Portfolio Optimization			Integrated trading & dispatch strategy ↑ Revenue ↑ Profitability
 Operations Optimization	Fleet Excellence	PowerUp* Services	Digital Plan of the Day		Efficient & high performing fleet ↑ AEP ↑ Productivity ↑ WTGs/Field Engineer
 Asset Performance Management	Machine & Equipment Health	Reliability Management	Asset Strategy Optimization		Financially optimized maintenance approach ↑ Reliability ↑ Availability ↓ Maintenance Cost ↓ Risk
 PREDIX	Integrated OT & IT Platform				Scalable & secure wind farm infrastructure Scalability • Cyber Security ↓ Risk
	Cyber Security	Digital Twins	Mobility	Controls	

Utilizing software to get the most out of your hardware over the lifetime of your fleet



GE Energy Financial Services

investing in renewable energy



- ✓ Navigate permitting, regulations, engineering & power contracts
- ✓ Structure a successful transaction
- ✓ Fund, build & optimize energy projects

~\$10B

In cumulative global renewable energy commitments

30+ years
Financing expertise

Global
Across 5 continents

~\$25B
In volume since 2004

Flexible
Unique equity & debt financing structures

EFS: a builder & a banker, providing flexible financing solutions for GE equipment

