Blade Lifetime Management – Data & AI

Sandia Blade Workshop '22
Albuquerque, NM
19th October, 2022

Ken Lee, Sr. Fleet Engineer

BIO

Current Role:

- **EDF:** Blades SME for Performance & Reliability Engineering, leading RCAs and improving long term blade health and risk management.

Prior Roles/Work:

- **Windcom:** Director of Eng. & Ops, Blade Services.
- **SkySpecs:** Sr. Blade Solutions Engineer, Blade SME.
- **Envision Energy:** Technical Lead - Structure Design.
- **Wetzel Engineering:** Engineering Lead/multiple roles on projects for OEMs and owner- operators.

Wind & Blades, 13Y:

- Rotor blade product development & engineering, testing, certification, advanced technology R&D.
- Blade inspections and monitoring, technical support and structural integrity advisory
- Composites repairs, blade repair tech training.
- In-factory and wind farm inspections, RCAs and NCR (non-conformance) dispositions.

Global Perspective

A Global Leader in Low-Carbon Energy

EDF Group

70+
years experience

$20.4 B
EBITDA

165,000
employees

37+ M
clients worldwide

EDF Renewables

$1 B
EBITDA

22
operating countries

4,300
employees

24.7 TWh
green electricity

EDF Renewables North America

24 GW
developed

13 GW
O&M contract

15 GW
pipeline

35+
years experience

1,500+
employees


Grid-Scale Power


Distribution-Scale Power


Onsite Solutions


Asset Optimization

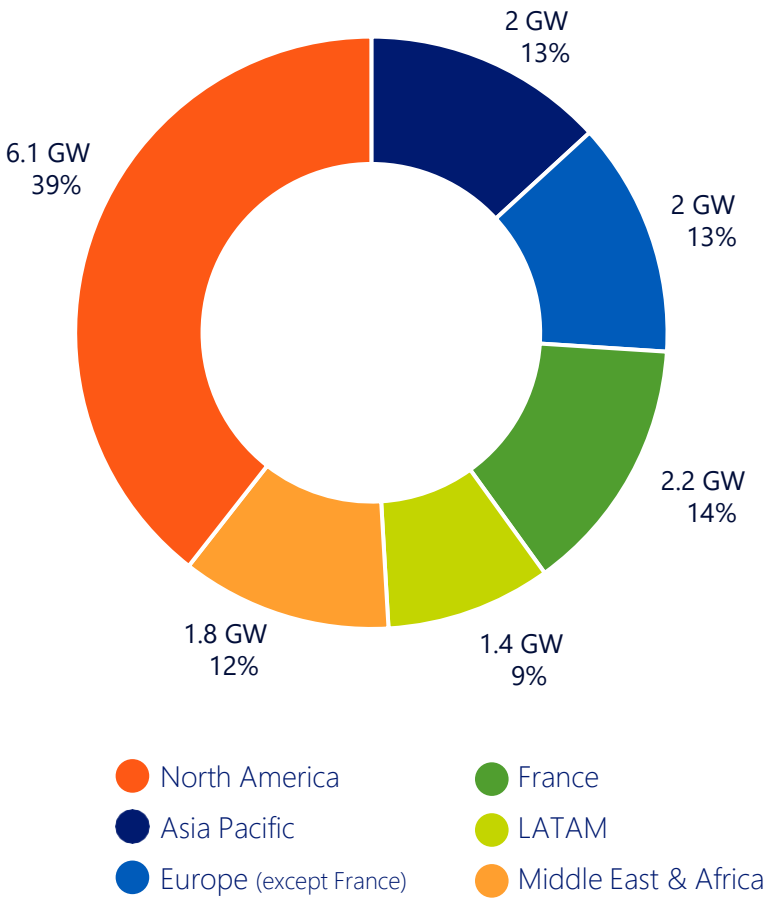
as of 12/31/21

EDF Renewables Global Capacities

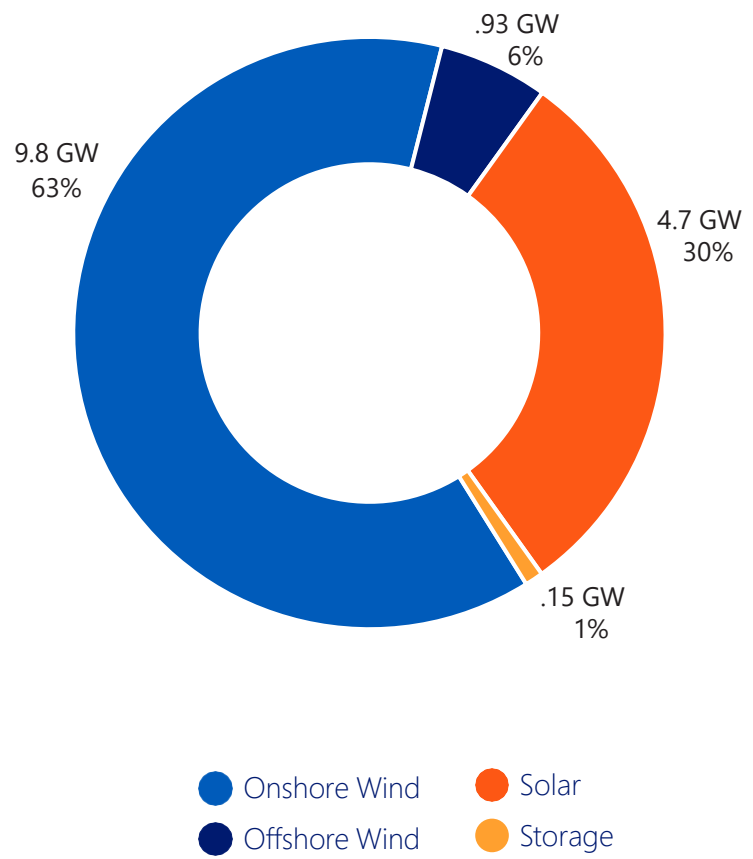
15.6 GW gross

as of December 2021

Region



Technology



North America

EDF Renewables **North America**

GRID-SCALE POWER

Bigger projects. Bigger impact.

Grid-Scale Power provides origination, development, and construction services for large-scale wind (offshore and onshore), solar power generation and storage projects across North America.

Our team of leaders can solve energy challenges facing businesses and communities no matter the size or complexity.

DISTRIBUTION-SCALE POWER

Experienced. Reliable. Integrated.

The Distribution-Scale Power team provides industry-leading, cost-effective development, engineering, construction, and operations of solar and storage projects.

Solutions are customized for utilities, co-ops, landowners, communities and institutions. Specializing in community solar and environmentally sensitive sites.

ONSITE SOLUTIONS

Multiple solutions. One point of contact.

Onsite Solutions are provided through our PowerFlex subsidiary. Offering onsite solar, battery storage, electric vehicle charging, microgrids, and energy management.

The suite of flexible, turnkey solutions is designed for corporates, institutions and other organizations to achieve their sustainability goals and reduce energy costs.

powerflex
EDF Renewables

ASSET OPTIMIZATION

Accelerate operational excellence. Drive profit.

The Asset Optimization team offers a full range of services for all phases of renewable energy projects – operations, management, procurement, routine and emergency maintenance, retrofits and upgrades.

Our experienced team of 400+ experts means EDF Renewables is fully equipped to manage the balance-of-plant and day-to-day operations of your wind or solar project.

EDF renewables

EDF-RE Wind Assets in **North America**

3000+
WTGs
Installed
(US & Canada)

4
Major OEMs – GE,
Senvion/RePower,
SWP/SGRE, Vestas

~10,000
Blades
In Service

EDF Blade Management Team

PRE

Performance & Reliability Engineering, Multi-disciplinary Team – Systems, Analytics, Reliability

CRS

Composite Repair Services, Specialists & Lead Techs

AO

Asset Optimization, Technical Services Support to Asset + Site Management

EDF Blade Fleet Management

~11,000
WTGs Inspected,
2017 - 2022

30 – 70m
Multi-OEM blades

100%
Fleetwide, Annual
Inspections since 2019

Contents

1

What is Data Analytics?

- Examining raw data, identify trends, drawing conclusions.
- Simply: Looking at (a) what happened *(Descriptive)* (b) why it happened *(Diagnostic)* (c) what will happen *(Predictive)* (d) what should be done next *(Prescriptive)*.

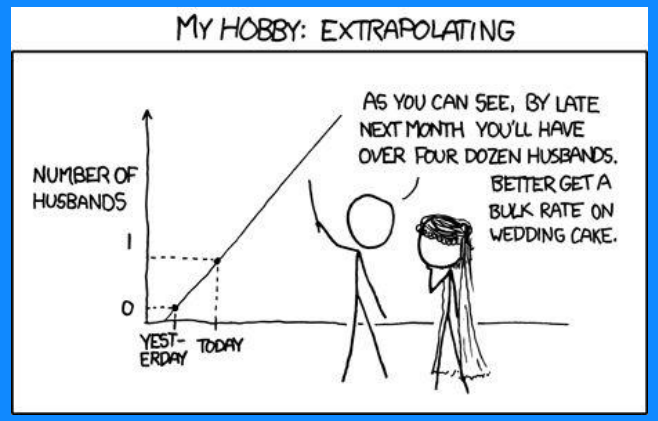
1

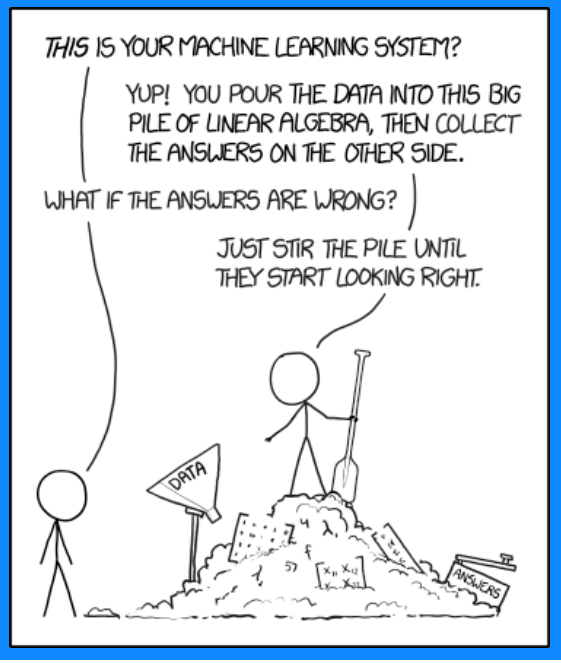
What is AI?

- Artificial Intelligence: Machine learning systems or algorithms, mimic human intelligence and decision-making.
- Alternatively: Actionable Insights – Leveraging structured data & models to identify trends and raise alerts/alarms, so that we can take action.

Process Involves:

1. Data collection
2. Organizing & cleansing
3. Number crunching
4. Model formulation
5. Deriving useful information





Images Courtesy of:
https://www.analyticsvidhya.com/blog/2015/12/hilarious-jokes-videos-statistics-data-science/
https://www.analyticsinsight.net/hilarious-data-science-jokes-on-the-web-to-lighten-your-mood/

2

EDF's Blade O&M Data

- Blade inspections & repairs
- SCADA – performance, availability, operational losses
- Service provider & blade inspection/repair cost database
- Workflow management platform (MCRs, WOs, Logs)
- Weibulls & component failure rate database
- Technical OEM docs & RCA reports
- **CBM sensors (still very nascent)

EDF Blade O&M Database Focus

Inspections
Damages & Defects

Repairs
Remediation & Cost

Failure Database
Reliability Centered Decision-Making

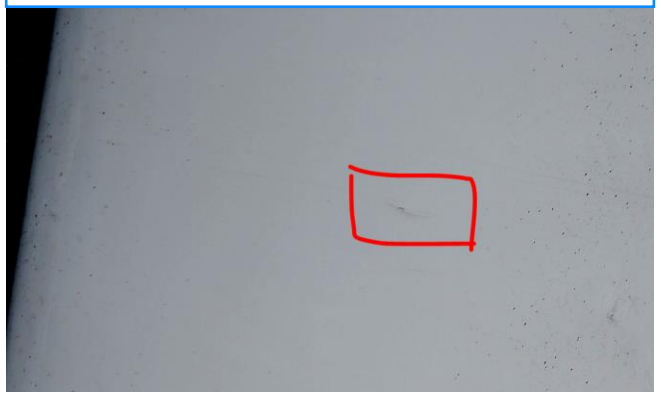
3

Blade Inspections

Data Toolbox:

- Visual inspections, drone-assisted or manual by technicians.
- Tap test or Advanced NDT – UT, X-Ray, Thermal.

Damage 1



Damage 2

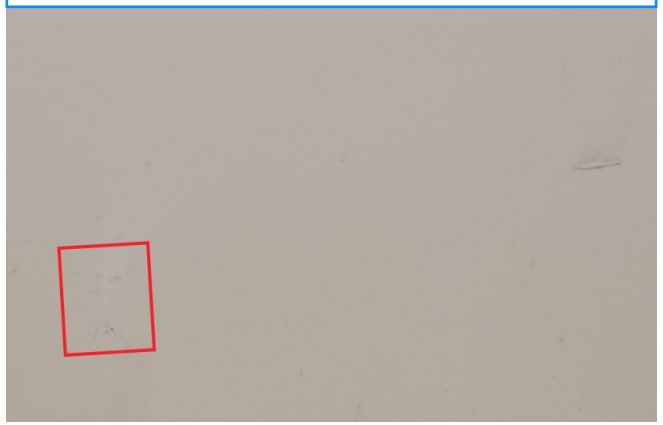
H-Cracks

Damage Progression & Repair Tracking

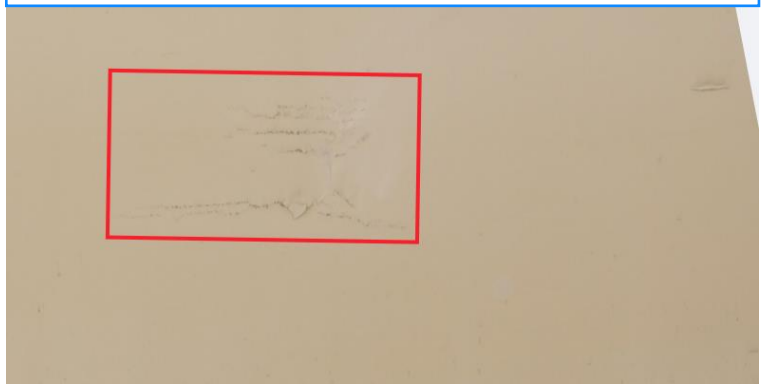
2020

2022

2019

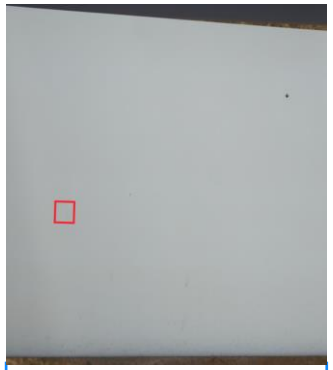


2021



H-Cracks

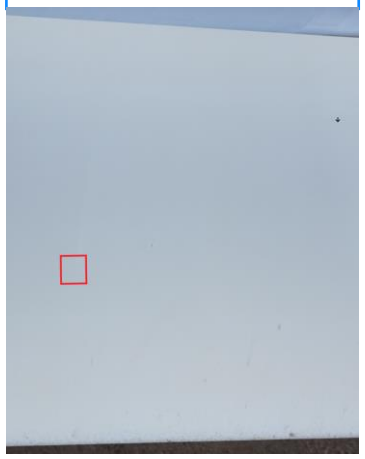
Damage Progression & Repair Tracking



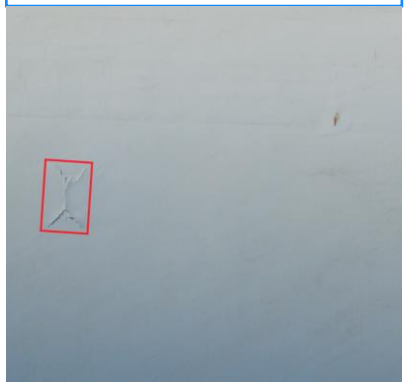
2020

2022

2019



2021



3

Blade Inspections

Data Value:

- Damage database and condition monitoring.
- Critical damage progression.
- Detect key defects and prevent its non-repairability.
- Focus on high-risk assets to prescribe continuous monitoring solutions.

3

Blade Inspections

Data Challenges:

- Consistent damage categorization based on inspection methods.
- Depending on inspection method, data may lack consistency.
- Sometimes too much data or defect findings that are non-critical.

3

Blade Repairs

Data Toolbox:

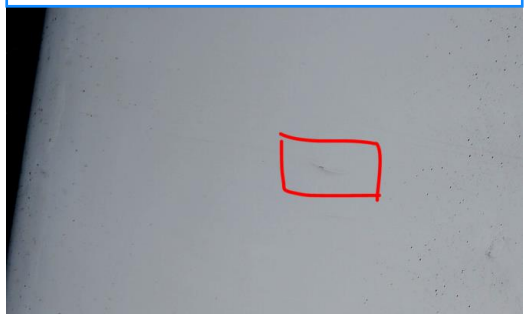
- Repair Reports: E-mailed PDF or Mobile E-forms.
- Daily progress reports, PODs & work logs.

H-Crack

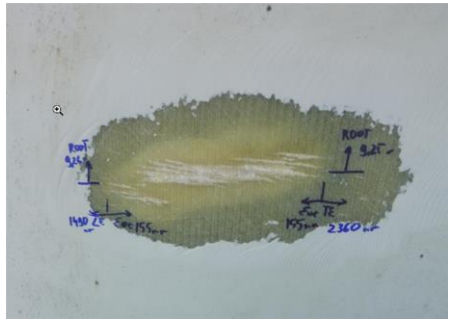
Exploring Damage Depth/Extent

Initial Condition

Damage 1



Exposing Damage



Expanding Boundary

Layer & Material ID

H-Crack

Exploring Damage Depth/Extent

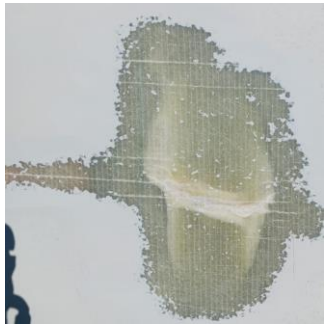
Initial Condition

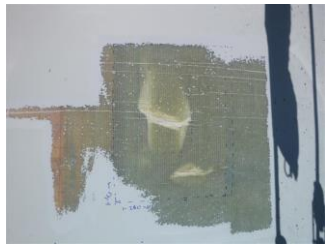
Exposing Damage

Expanding Boundary

Layer & Material ID

Damage 2





3

Blade Repairs

Data Value:

- Deeper extent of damage revealed.
- RTS dispositions.
- Annual blade maintenance planning/budgeting & YoY tracking.
- Service provider performance & quality evaluations.
- Identifying/reducing gap between actuals –vs- estimates.

3

Blade Repairs

Data Challenges:

- Varying results, reports sometimes lacking details.
- Time lapse between executed work & report delivered.
- Challenging to perform real-time repair QC/QA to prevent rework.

3

Blade Failure Modes & Failure Rates

Data Toolbox:

- Damage information, occurrence, frequency
- **FMEA
- **Weibulls & lifetime calculations

3

Blade Failure Modes & Failure Rates

Data Value:

- Risk evaluation & failure forecasting – existing O&M budgets & pro-formas for future projects.
- Evaluate tradeoff between risk & cost for inspection/repairs.
- Prescribe Risk-based (RB) approach – decision modelling (repair/inspect)

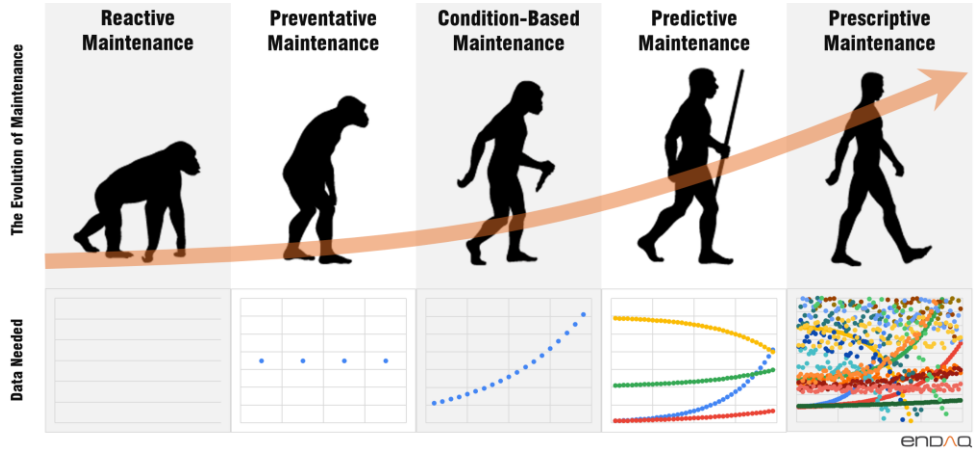
3

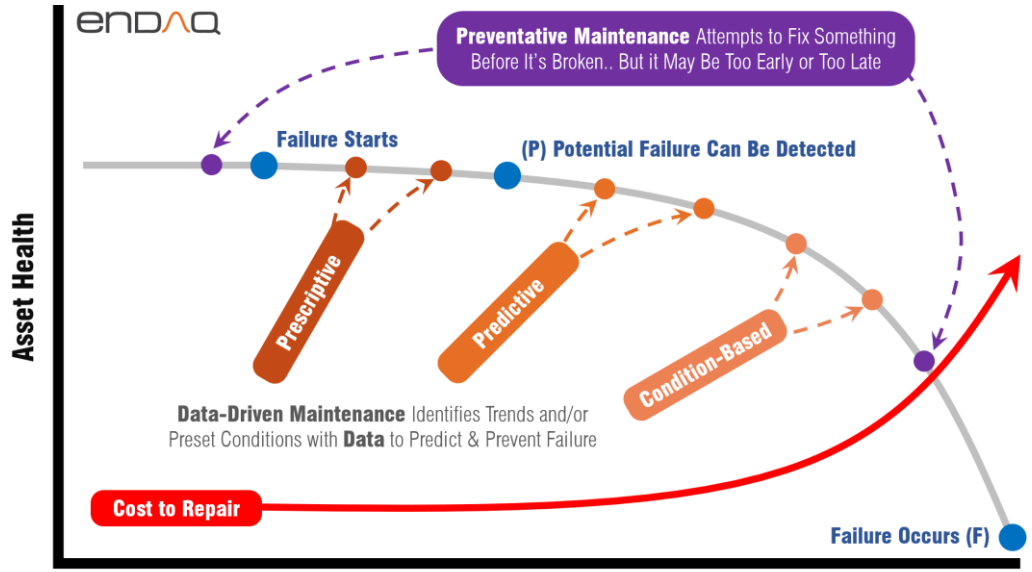
Blade Failure Modes & Failure Rates

Data Challenges:

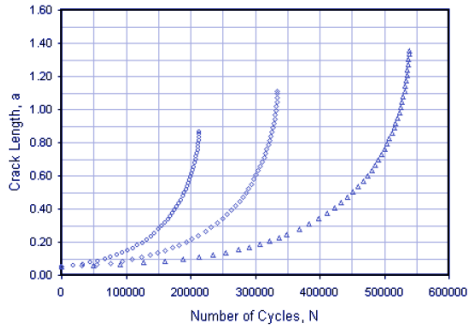
- Structured data, not easily accessible to review and evaluate.
- Lot of time spent reviewing/cleaning/re-categorizing.
- No straightforward way to visualize damage progression.

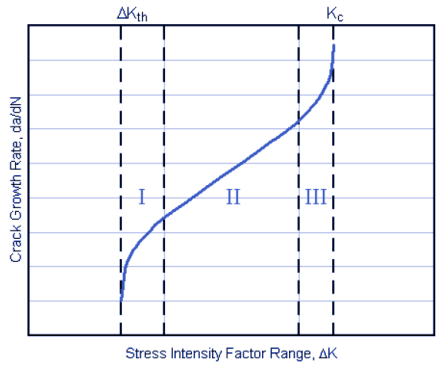
Why are we focusing on data?





- Maturing blade management programs.
- Understanding damage initiation, growth & propagation to functional failure.
- Tailor blade SHM tech solutions to complement RB methods.





Images Courtesy of:
https://blog.endaq.com/differences-between-condition-based-predictive-and-prescriptive-maintenance
https://www.engineersedge.com/material_science/fatigue_crack_growth_analysis_review_10071.htm

Concluding:

- Standardization - Data collection & representation.
- Centralization – Multi-sourced data in single place.
- Systematic approach to risk quantifcation.
- Continuous Improvements – Deriving most value from data.

Ken Lee
Sr. Fleet Engineer – Mechanical & Composites, Performance & Reliability Engineering, EDF Technical Services

Phone: +1 (858) 521-3398
Email: ken.Lee@edf-re.com

edf-re.com

STAY CONNECTED

EDF renewables