GREENBYTE

From PhD to Product

Elkraft 2017

GREENBYTE

Our Vision & Mission

Our vision

A sustainable world
powered by renewable energy.

Our mission

Making renewable energy more abundant
and profitable by providing renewable
energy owners and operators with state of
the art software services.

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The world of energy is changing and data is playing an integral part in the ongoing transformation.

Nature of renewable energy

The distributed nature and volatile production of wind and solar entails a plethora of optimization decisions/actions.

Fragmentation of power generation market

Utilities are no longer the dominant players in all major energy markets. Increasing fragmentation in terms of ownership, production, O&M, sales and consumption of energy.
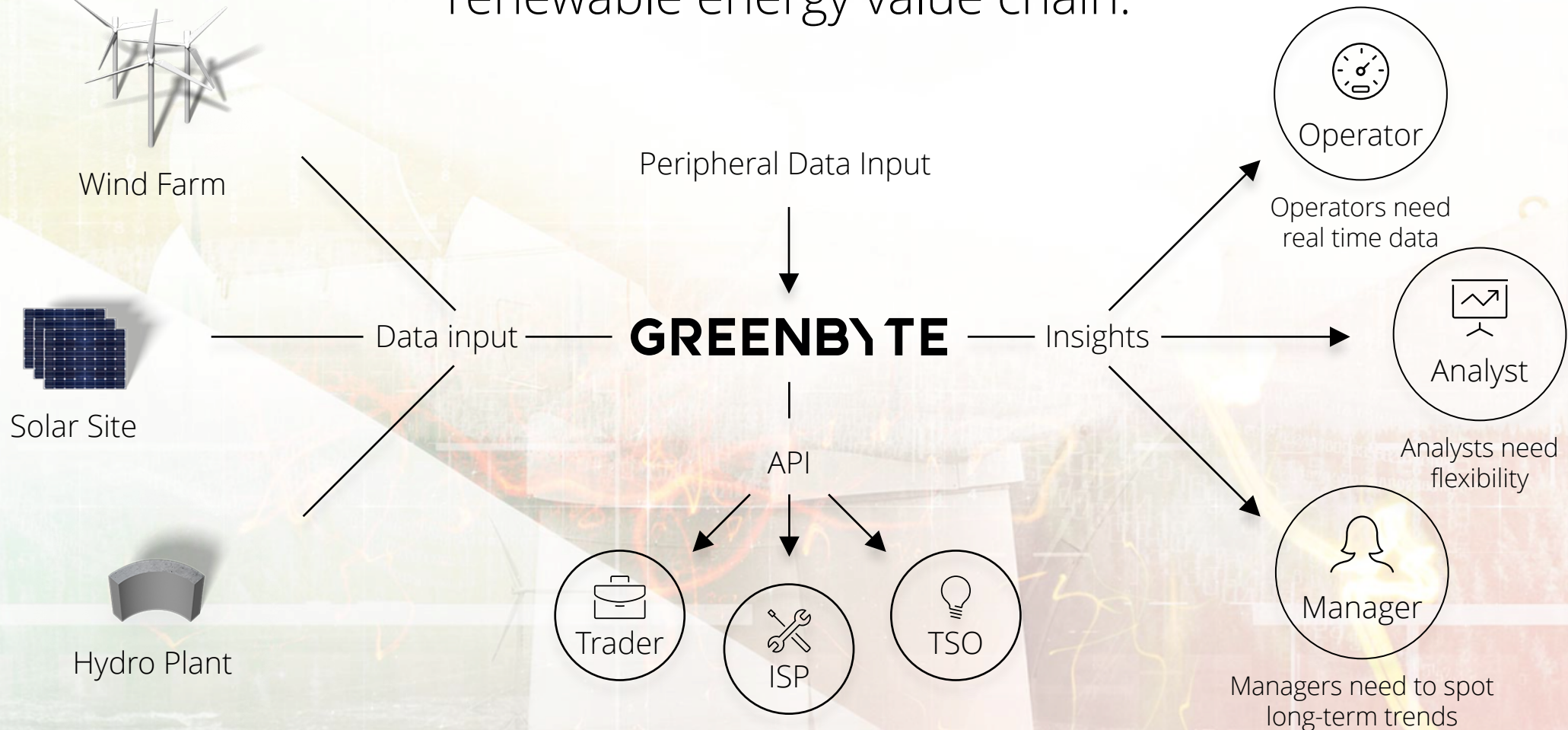
Emergence of industrial internet

Data is collected in the production, distribution and consumption of energy. Many outside data sources complete the picture including met data, electricity prices etc.

Translating data into actionable insights will be a key competitive advantage in the evolving energy landscape in terms of:
Enhancing renewable energy asset performance & operations, energy trading and other transactions

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Greenbyte services transform data into actionable insights for all stakeholders in the renewable energy value chain.

Wind Farm

Solar Site

Hydro Plant

Peripheral Data Input

Data input

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Insights

API

Trader

ISP

TSO

Operator

Operators need real time data

Analyst

Analysts need flexibility

Manager

Managers need to spot long-term trends

Key Customers

France
110 MW
Customer since 2016

USA
2000+ solar sites
Customer since 2015

Canada
33 MW
Customer since 2015

Belgium
593 MW
Customer since 2015

South Africa
207 MW
Customer since 2016

UK
890 MW
Customer since 2014

Netherlands
150 MW
Customer since 2014

Germany
880 MW
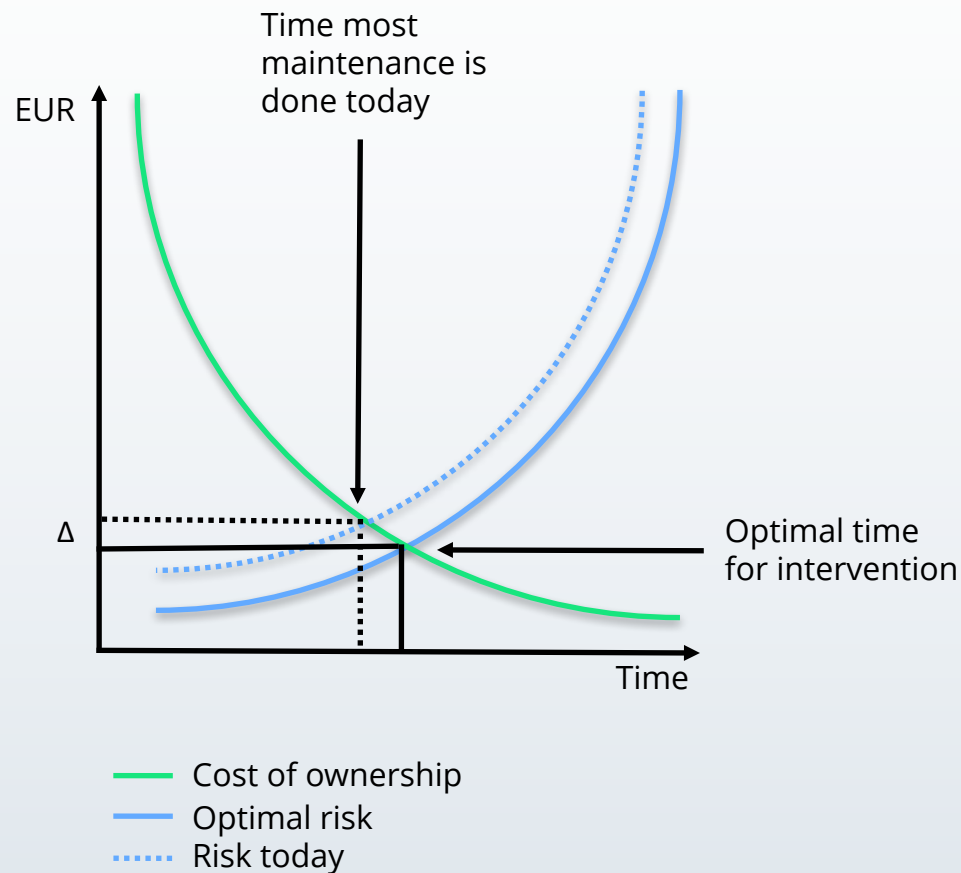Customer since 2015

France
270 MW
Customer since 2015

Sweden
335 MW
Customer since 2014

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Key challenge next few years is to reduce OPEX

EUR

Time most maintenance is done today

Δ

Optimal time for intervention

Time

— Cost of ownership
— Optimal risk
···· Risk today

High margin of failure results in low profitability

- Most wind farms operate with too much margin of failure resulting in high OPEX and low returns. Especially true for large portfolios where potential is greatest to decrease margin of failure.

- Δ is a bEUR challenge years to come

- Better data in the hands of operators will result in capabilities to make more optimal decisions and less dependence on turbine manufacturers

Example of features required to operate closer to optimum

- Map bill of materials in uniform taxonomy and identify critical components

- Predictive analytics to know when components are likely to fail

- Link predictive analytics to scheduling

- Sourcing of spare parts

Three Methods to Look into the Future
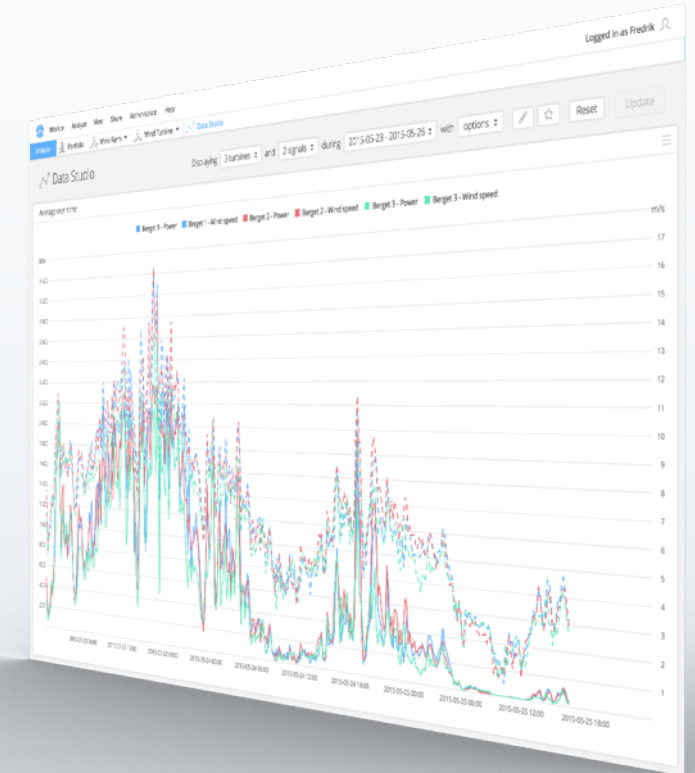
1. Statistical Model

✔ Component lifetime estimation

✔ Provides estimation uncertainty

✘ Requires large data sets with component failures
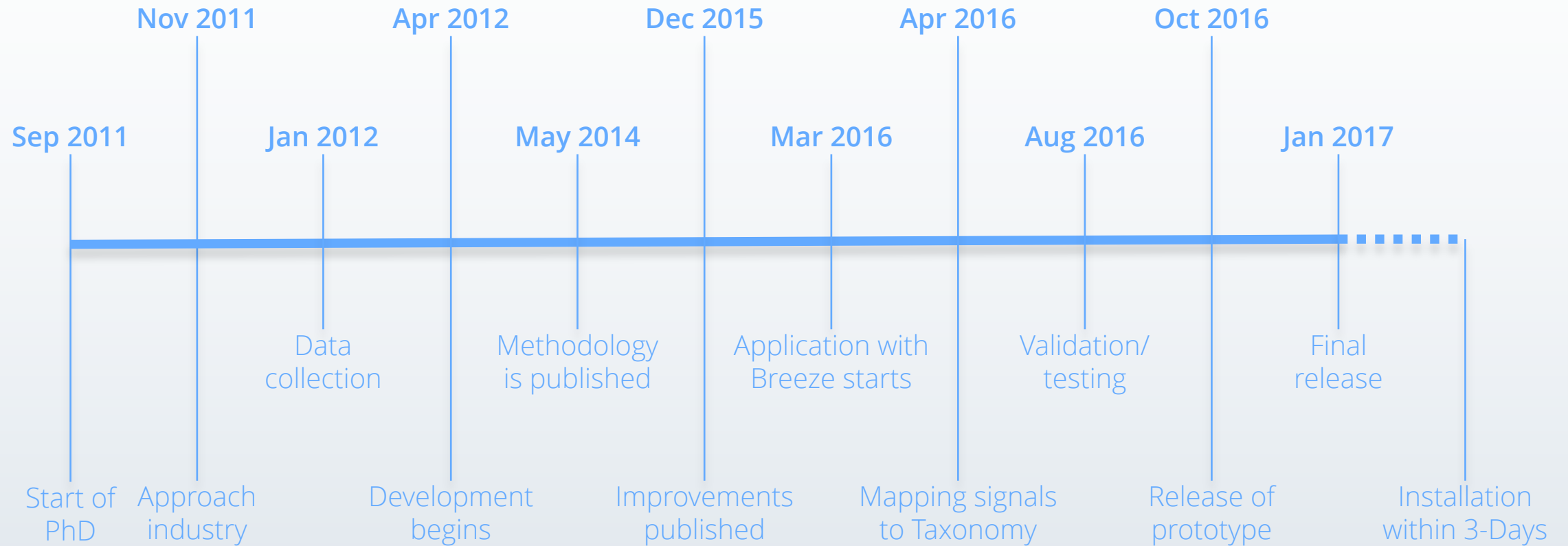
✘ Difficult for user to understand

2. Physics Model

✔ Provides a clear understanding

✔ Accurate, great for engineering

✘ Applies to limited set of failures

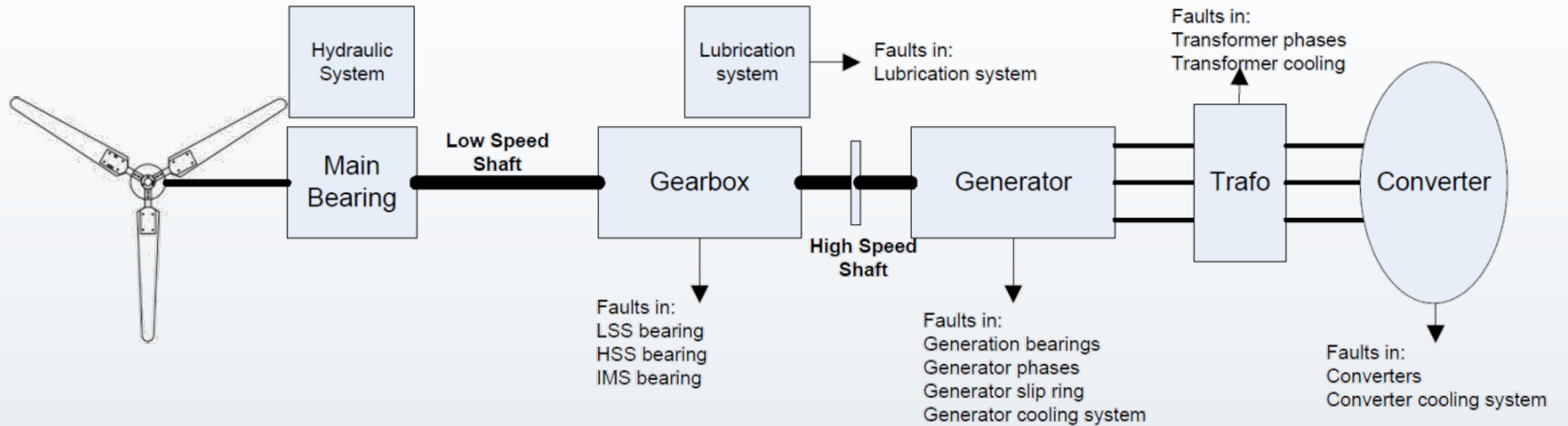✘ Challenging to create, may need tests if applied as CMS

3. AI Model

✔ Can be applied with common data sets, like SCADA

✔ Use as CM for different components in the wind turbine

✔ General, no need for deep component understanding

✔ Scalable, can be used for large scale applications

✔ Provides uncertainty in prediction

✘ Difficult for user to understand

✘ Unchartered territory for wind, researched but not applied at scale

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Academia & Industry Collaboration

Sep 2011 — Start of PhD

Nov 2011 — Approach industry

Jan 2012 — Data collection

Apr 2012 — Development begins

May 2014 — Methodology is published

Dec 2015 — Improvements published

Mar 2016 — Application with Breeze starts

Apr 2016 — Mapping signals to Taxonomy

Aug 2016 — Validation/ testing

Oct 2016 — Release of prototype

Jan 2017 — Final release
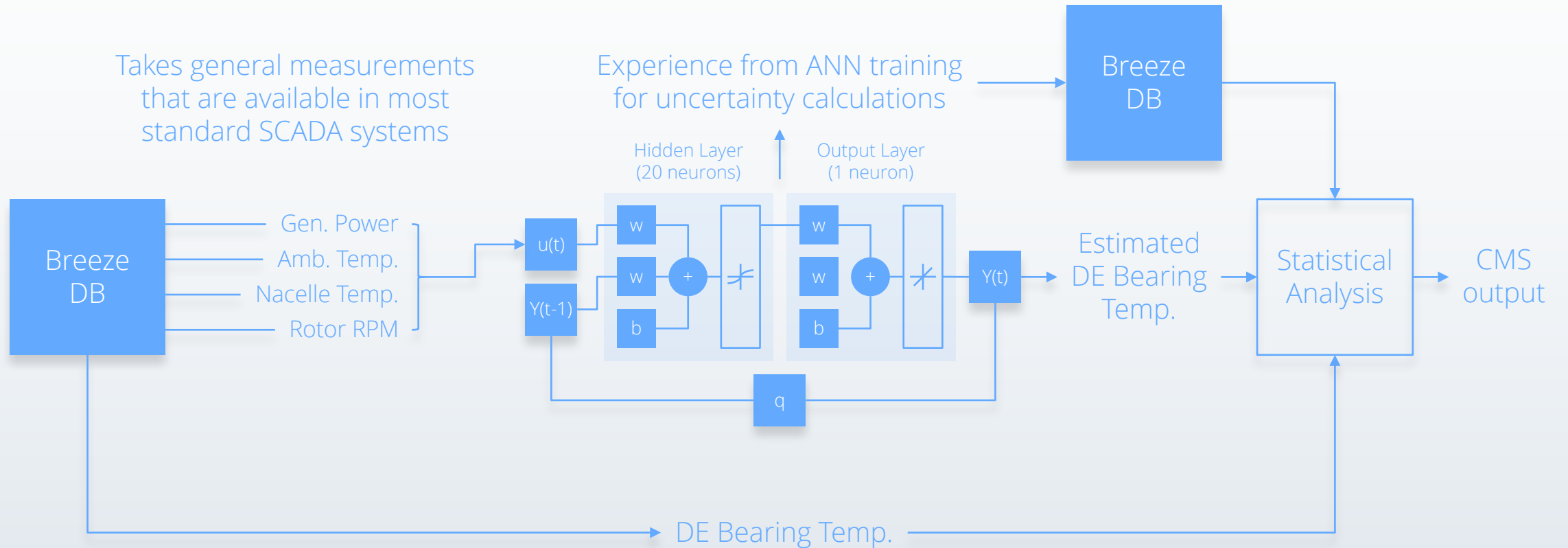
Installation within 3-Days

A wind turbine consists of a number of components.

*For Breeze ANN we have applied the Reliawind Taxonomy as suggested by IEA Task 33
Recommended practices for O&M in Wind Turbines.

Results are very promising

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Holy grail
- Prediction is a game changer for OPEX reduction and lifetime extension
- Greenbyte to play a leading role within the digital space of renewables

Status today
- 17 Artificial Neural Networks (ANN) trained per WTG identify "abnormal" temperature developments in key components
- Developed on a Vestas wind farm and currently rolled out on 15 wind farms (Vestas, Enercon and Nordex).

Validation
- Initial model has identified 100% of generator and hydraulic system break downs 2-9 month ahead of time.
- Gear box prediction only at 30%, but with no false alarms.

Next steps
- Integrate seamlessly into Breeze (graphical user interface, communication protocol with client...).
- Improve prediction quality further
- Expand WTG base

Results from initial validation

Method

- **Data input:** 1 year of SCADA data and maintenance reports from 18 wind turbines in 1 wind farm.
- **Identification of failures:** Manual review of maintenance reports identified 15 failures during the time period.
- **Model setup**: Breeze ANN models were setup for the components where failures were identified using SCADA data: Gearbox, generator, hydraulics
- **Model run:** Models were run and 11 failures were identified prior to failure. No "false" alarms were created.

Results

Component	# of failures	Failures detected by BANN	Av. lead time with BANN [Months]	Total down-time [h]
Gearbox	6	2	2	589
Generator	5	5	8.7	51
Hydraulics	4	4	7.5	43

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UI / UX Designer	Sales Manager Southern Europe
Graphic Designer	Technical Project Manager
Customer Success Manager	Senior Developer
Sales Manager Northern Europe	Junior Developer

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