TRANSFORMERS MAGAZINE'S
INDUSTRY NAVIGATOR

SUSTAINABILITY AND DIGITALIZATION

EDF Hydro's approach to sustainability and digitalization

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EDF

EDF Hydro GSU fleet

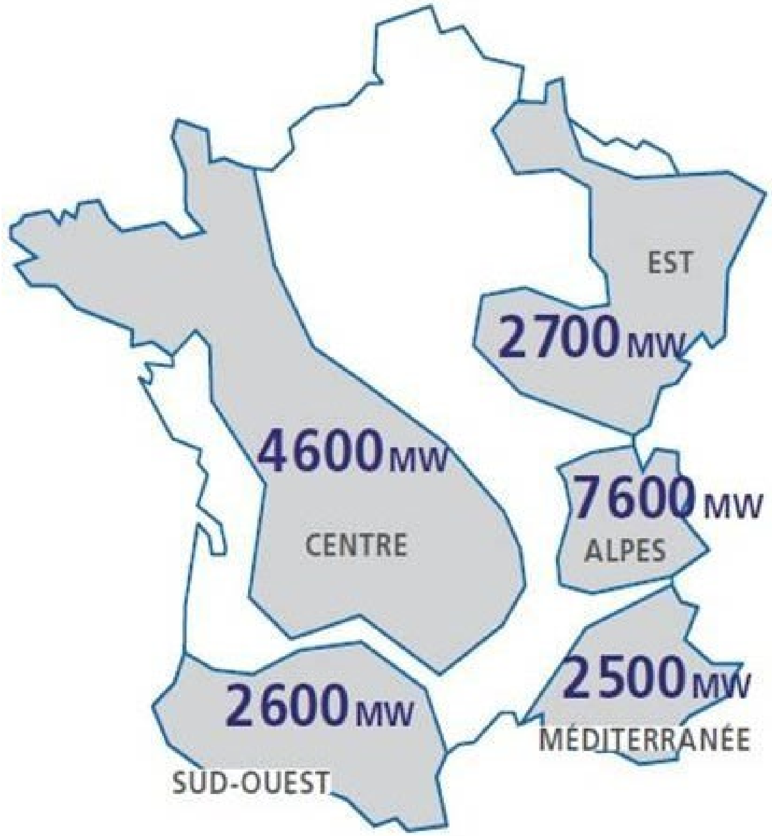
≈ 800 GSU power transformers
on 450 hydro power plants

Some big units, many small…
almost all uniques!

Up to 400 kV 370 MVA
GIS included

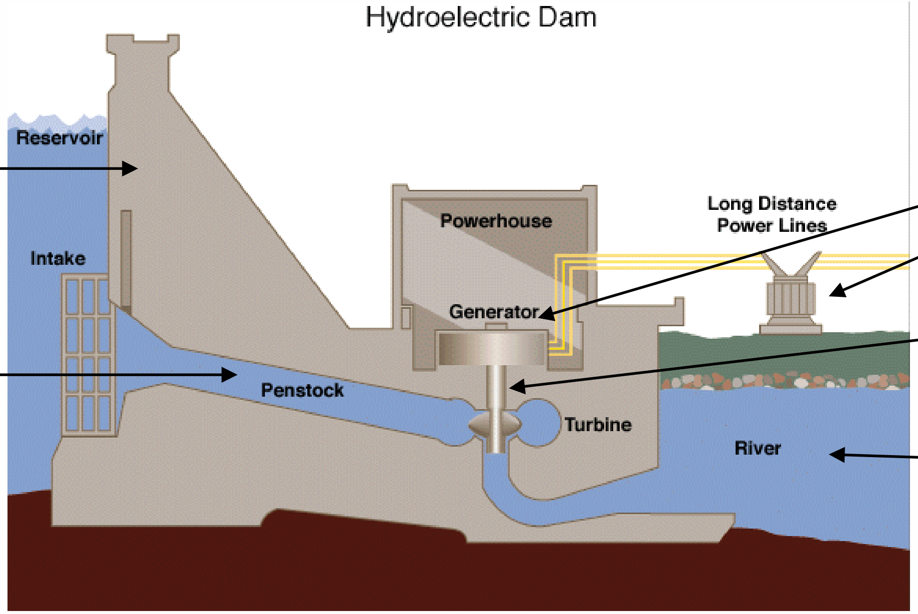
Business units of operations & engineering

French EDF Hydro capacity
(20 GW)



Global Sustainability View

More & more => approach to estimate global **LifeCycle Assessment / Carbon Impact**
=> to assess our impact + investment choices
=> on a whole hydro power plant… not that easy! Still in progress!
=> GHG footprint using an inhouse tool + Simapro for several years



Civil engineering

Hydromechanics

Electrical engineering
… of course ☺

Mechanical engineering

Environmental works/impacts

Source : Wikimedia
https://commons.wikimedia.org/wiki/File:Hydroelectric_dam.png

Global Sustainability View

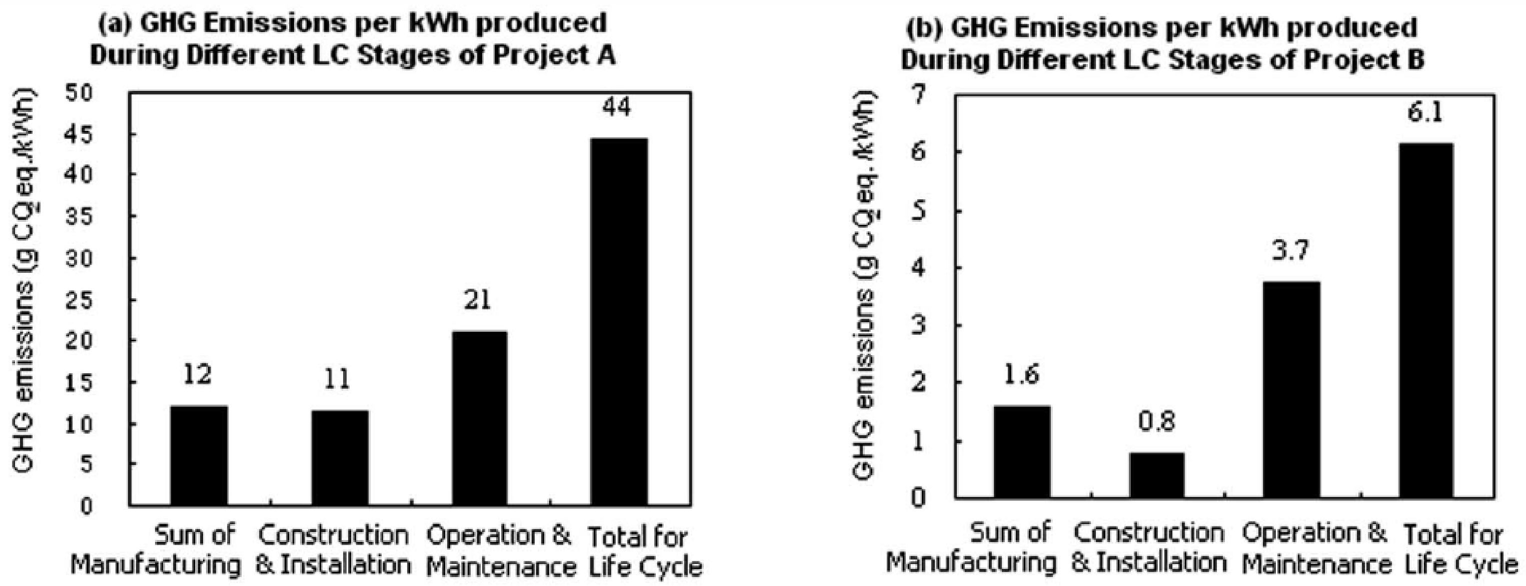


Fig. 5. Life-cycle inventory of GHG emissions for Projects A and B

Example from literature to compare GHG impact between 2 hydro projects

Source : Zhang, Qinfen & Karney, Bryan & Maclean, Heather & Feng, Jingchun. (2007). Life-Cycle Inventory of Energy Use and Greenhouse Gas Emissions for Two Hydropower Projects in China. Journal of Infrastructure Systems. 13. 271-279. 10.1061/(ASCE)1076-0342(2007)13:4(271).

Field case: New group of + 12 MW to existing plant

Site work	Preparatory work	Plant construction	River adaptation	Total (t CO_2 eq)
5 %	12 %	59 %	24 %	≈ 13 000

Plant construction has most impact… hydro work on the river is also significant!

+ Sensitivity analysis on main drivers:

	Base	Alternative	Gain (%)	Gain (t CO_2 eq)
Transport of people on site by car	Gasoline	Electric	- 25	166
≈ 1 100 t of steel production	North America	France	- 69	665
% of recycled steel	0 %	100 %	- 72	1 803
Concrete resistance class	40 MPa	20 MPa	- 27	827

Source : Internal EDF

Carbon impact of electrical equipment

EDF first "homemade" estimations, with Simapro on big electrical equipment

=> mass and CO₂ emission factors from OEMs when available…

=> hard to get significant ones! Still need to find the "right" emission factors…

- Manufacturing impact here
- Main drivers

240 MW / 290 MVA new plant	Transformer		Generator	
	Mass (t)	(t CO_2 eq)	Mass (t)	(t CO_2 eq)
Total	276	6 400	679	15 000
Core (electrical steel)	127	4 100	250	5 400
Tank / Frames+shaft (= steel)	50	1 700	340	8 100
Windings (= copper)	28	190	50	290

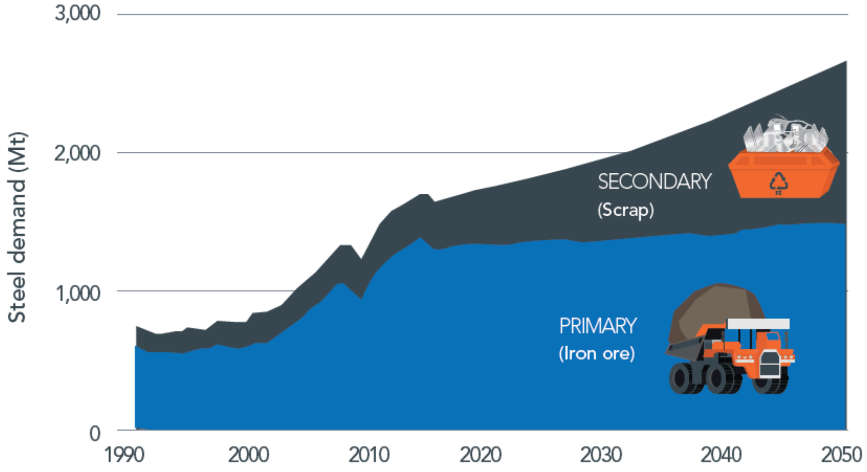
On carbon impact of transformers

=> Many interesting papers from Bhaba P. Das, Hitachi Energy, in Transformers MAGAZINE

Source : Internal EDF

Example: Carbon impact of steel

Steel	(kg CO_2 eq/kg)
From primary source*	**1.4 – 2.2**
From secondary source*	**0.340**
Chili : 1 champion ☺!: 100 % recycled + low carbon electricity @ 6.7 g CO_2/kWh!	0.286!
France: 68 % recycled + electricity @ 69 g CO_2/kWh	0.415
Korea: unknown % of recycled + electricity @ 514 g CO_2/kWh	2.820



Significant main drivers of steel manufacturing:

> % of recycled materials!

> Electricity g CO_2/kWh of manufacturing country

> Type of furnaces: *Blast Furnace / Direct Reduced Iron (+++)*
+ Basic Oxygen Furnace / Electric Arc Furnace (+++)

** Source : World steel*

EDF Hydro – Global impact of projects

More & more carbon footprint assessments, up to LifeCycle Assessment on hydro projects.

> *Few cases, but demand / regulatory requirements are growing, internal WGs on it.*

> **Most impact inputs**:

- Concrete (% and type of cement…) for civil engineering works
- **Steel**/copper **(type of furnace / part of recycled materials…)**
- Country of manufacturing and its electricity mix impact (g CO_2eq/kWh)
- Losses of electrical equipment (generators, transformers…) (impact +++)
- Use of construction equipment, gas or electricity fueled?
- Transport of all materials/people…

> Hard to get significant input data for a whole plant!

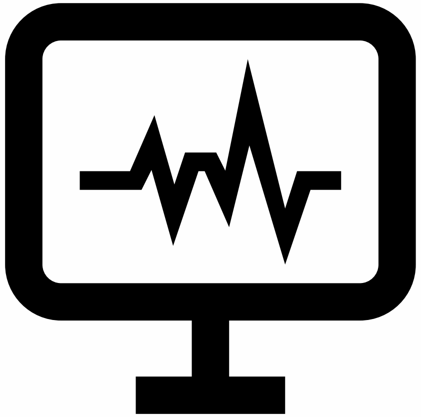
- Clear need to work with suppliers to assess at best their LCA/Carbon impact!

EDF Hydro – O & M… & Monitoring!

To **lower economical + global impact** => objective: long lasting equipment… with **monitoring**!

Since ≈ 10 years ago, EDF Hydro decided to **monitor its most strategic plants** on:

> Generators
> Transformers (good! ☺) mostly with DGA monitoring
> Turbines
> Penstocks
> Mechanical shafts
> Grid services (voltage/speed controls/regulations according grid codes)



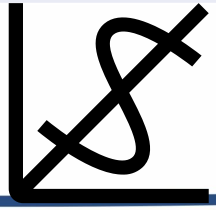
On: Temperatures, Pressures, Vibrations, DGA, Operational times (valves…)…

Built 5 dedicated monitoring centers to assess most of the "live data".

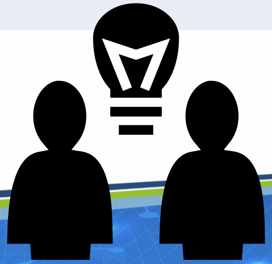
=> Key points to monitoring are: **"Which data, and who is using it <u>practically</u> ?"** ☺

EDF Hydro – Monitoring… organisation

	Who	When	What	Alarm
Level 1 Plant	Plant operations technicians	24h/24h	Live operations' surveillance	Live alarms / protections onsite
Level 1 Monitoring	Monitoring center (≈ 2/3 people, mostly from plants)	Daytime	Live monitoring/check on alerts/alarms on all data/devices!	« Self » specified, below protection settings
Level 2	Support to monitoring center (≈ 2 engineers)	Weekly	Tendency checks on medium/long term.	Statistical tools
Level 3	Experts (from many business units)	On demand	Investigations / specific tests / assessments and recommendations, as needed	-

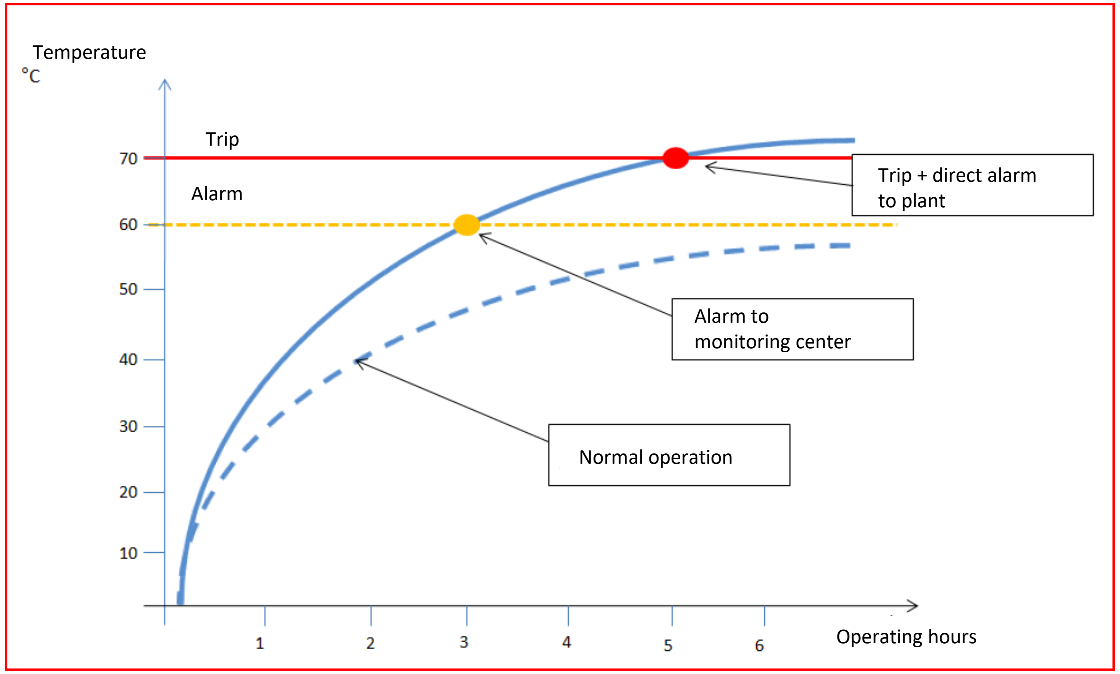


Team work ☺

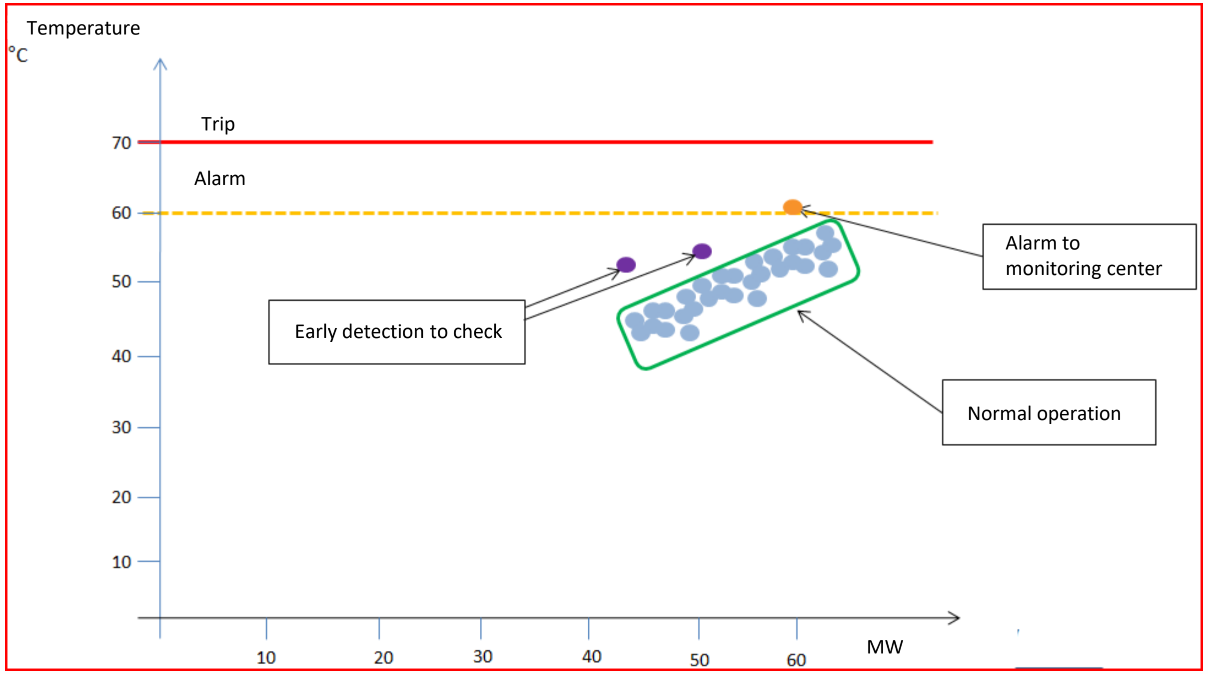


EDF Hydro – Monitoring alarms

Short-term alarms



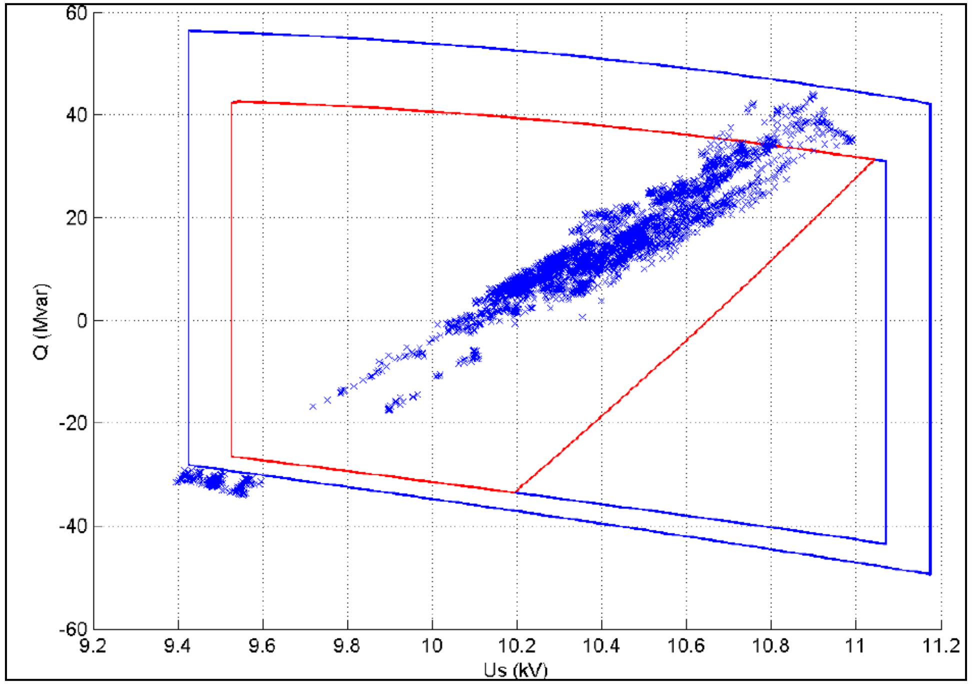
Medium/long-term alarms



EDF Hydro – Monitoring long-term tendency

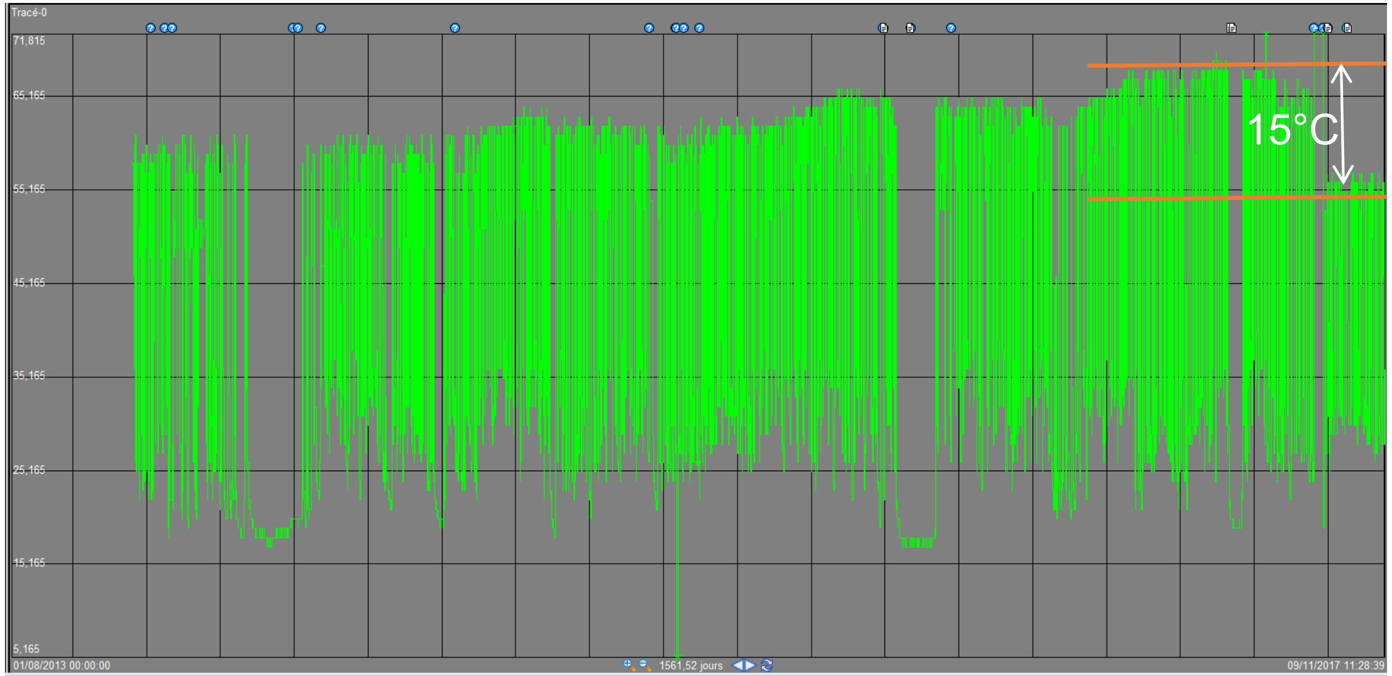
Example: U/Q of group delivery

Comparison of operations to settings & TSO contract



Example: Bearing temperature over 4 years

Mechanical inspection + move of 0.05 mm of one pad => -15 °C!

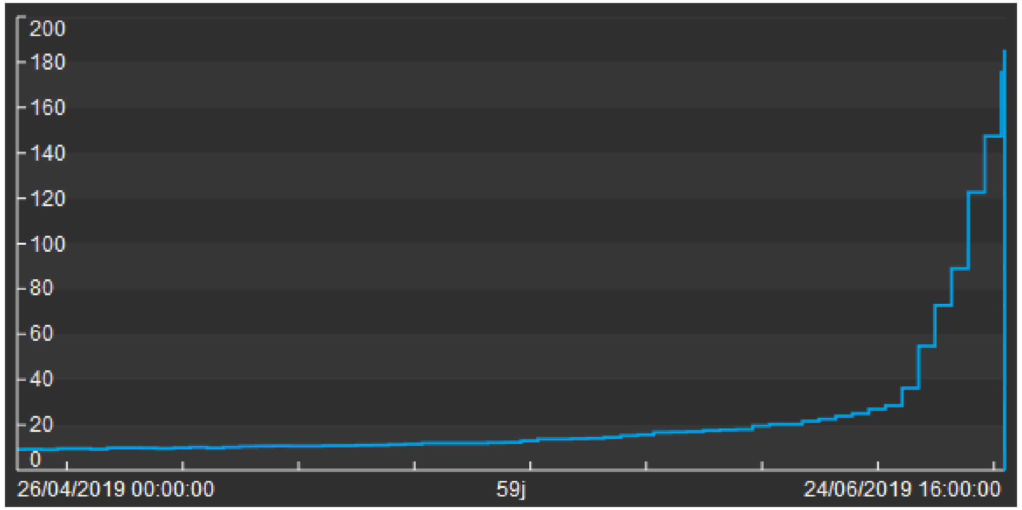


EDF Hydro – Monitoring of 250 MVA GSU

18 / 400 kV GIS from 1981
5 limbs core design
No specific issues

2019: **H2** => Increasing Partial Discharges (PD) over months!

Alarm by monitoring center + global investigations

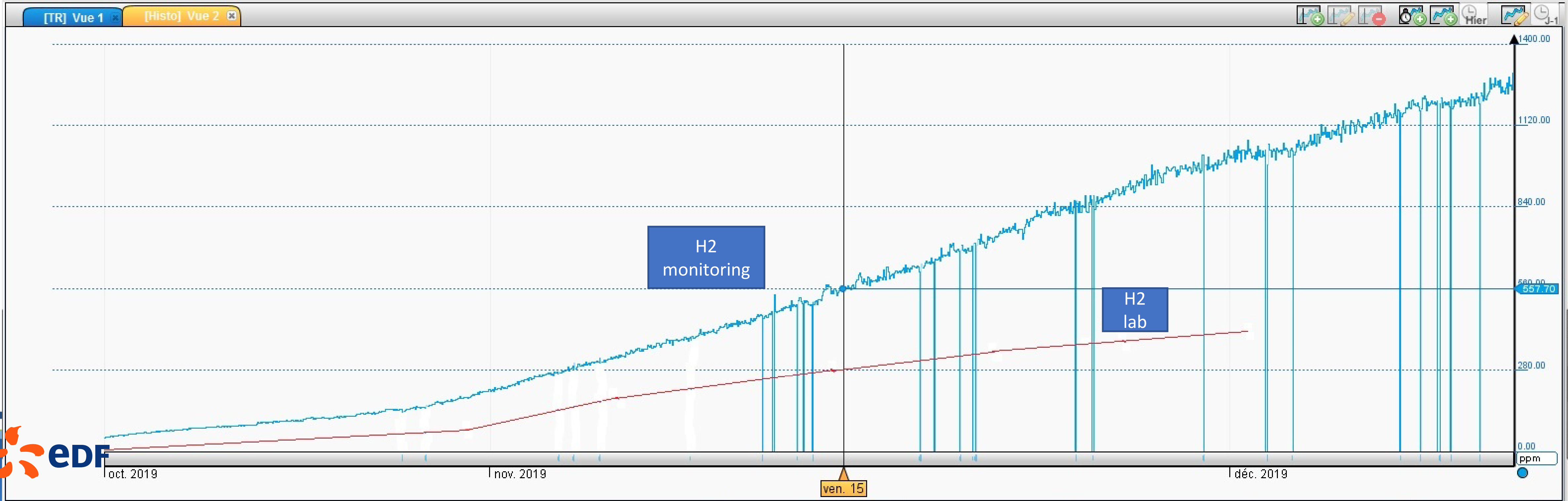


EDF Hydro – Monitoring of 250 MVA GSU

With > 3 000 ppm of H2 => oil treatment in October 2019 to NOT saturate H2 DGA sensor…
and **still be able to know the tendency**!

> Then H2 increased again… as we didn't fix the problem, just the way to measure it ☺

=> THE tricky monitoring question… where to stop?

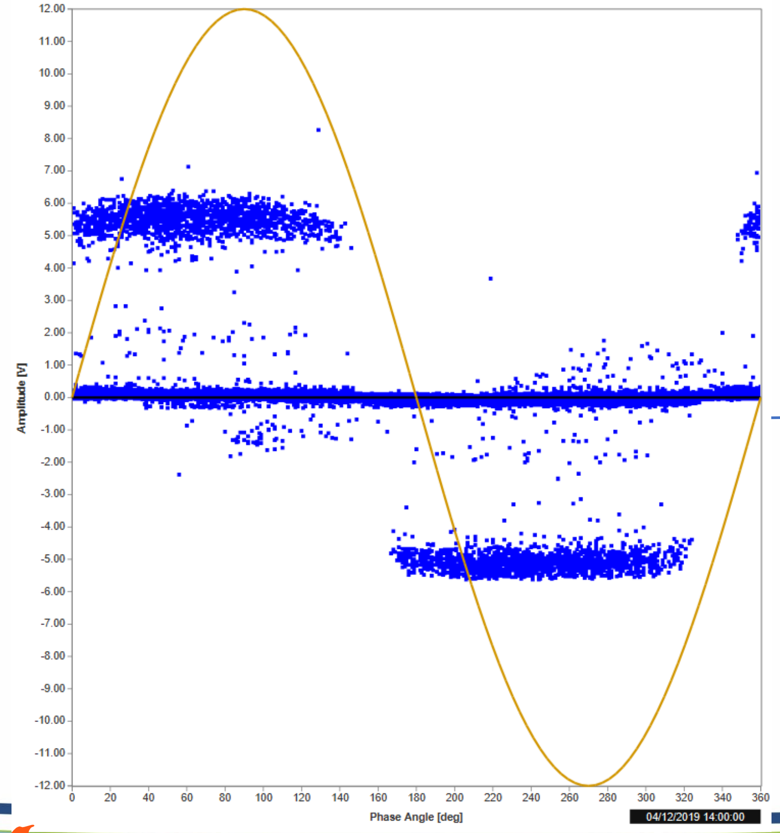


EDF

EDF Hydro – Monitoring of 250 MVA GSU

Then, added « bushing » monitoring, for PD measurements in service:

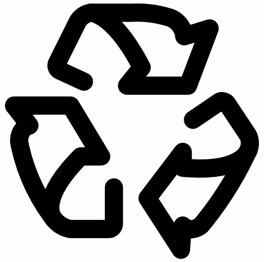
> Floating potential on PD => and on inspection! => victory of monitoring + teamwork ☺ !



EDF Hydro – Conclusion

On the sustainability of whole hydro plants:

> Going from carbon footprint assessment to life cycle assessment… still in progress!



> Materials/Steels: clear difference on recycled % and type of furnace.

> Need to work with suppliers for significant assessment and improvement.

On digitalization… to keep sustainable plants:

> Monitoring is going on… more and more in the field ☺

> WHO analyze the data is key point! Organization is needed!

> Digitalization + teamwork… works! In field cases ☺

Thank
You
For
Your
Kind
Attention
☺