
AVEVAWORLD
PARIS

AVEVA WORLD
PARIS

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Improving operational efficiency with an innovative approach to data utilization

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AVEVA

World’s leading producer of net-zero electricity

90% carbon-free electricity generation

Europe’s leading hydroelectric producer

A global leader in wind and solar

Europe’s top investor in energy transition

with € 16,4 bn of investment

Almost 180,000 collaborators in the world

with 75% located in France

Recruitment in progress of 20,000 more

First major French company to calculate its #impactscore

a framework that enables businesses to comprehensively assess their impact

OUR PURPOSE

To build a net zero energy future through electricity and innovative solutions and services,
contributing to environmental sustainability, well-being and economic growth.

EDF Hydro Division in video

Who in the audience has ever asked themselves one of these questions ?

How to :

- Minimize the time spent to deploy AF template instances and enable users to do it ?
- Automatically generate AF hierarchies from the company’s asset repositories ?
- Extend AVEVA PI System features ?

Answering these questions was our challenge

Inventory of use cases

- Back in 2020, the Hydro monitoring and performance communities were considering the creation of more than 80 AF templates
- We classified the expected AF templates in 3 categories using 3 criteria :

	Algorithm complexity	Input Parameters (Number and complexity to find the static values)	Number of expected instances
Light	Simple	Few or no	Any
Medium	Simple to moderately complex	Few to many	> 25% of the fleet
Heavy	Moderately complex to complex	Many	> 50% of the fleet

Non exhaustive list of expected AF templates

Light	Medium	Heavy
Averages	Calculation of startup and shutdown sequences of generation unit in all operating modes	Power plant and generation unit efficiency calculation + link to a Digital Twin
Totals	Linear regression	Head losses monitoring
Gradients	Duration to a state since a date	Linear interpolation (1 & 2 dimensions) using abacuses
Polynomial calculation	Sensor monitoring	Estimated date of the next Pelton Wheel inspection
Apparent power	Generation unit braking time	Alternator refrigerant fouling indicator
Number of occurrences	Asset operating time	Time counter after coupling a unit to the electrical grid
Distance traveled by a moving asset	Monitoring of reservoir elevation constraints	Threshold exceedance (several thresholds, Hysteresis…)
Edge counter	Duval Triangle (transformers)	email and SMS notifications
Deviation from the flowrate specifications	Asset maneuvering time	Counting of intermittency cycles
…	…	…
50 %	**25%**	**25%**

We estimated the distribution of the 80 planned templates based on the categories

Deploying instances of an AF template

Is it suitable to use AVEVA tools (PI System Explorer and PI Builder) to scale up ?

- We decided to test the manual deployment process, on a medium complexity AF Template :
  - Calculation of the startup sequence of hydro generation units in generator mode (over 700 for that template)
- It took nearly 60 days to deploy the instances for just 30% of the fleet, involving hundreds of emails and Excel files
- By extrapolating, it could take more than 160 days to deploy the AF template on the whole fleet

		Progress	
		30%	100%
PI Team	Development & testing on Ancillary	**9**	9
	Deployment on ancillary & production	**25**	83
Monitoring Community	Development & testing on Ancillary	**5**	5
	Deployment on ancillary & production	**20**	67
		59	***164***

- We took a break to ask ourselves the right question : **Is this manual method viable in the long term ?**

Deploying instances of an AF template

- We estimated the workload for each team (PI & Hydro Communities) based on the categories :
  - for the manual process
  - for a potential automated process

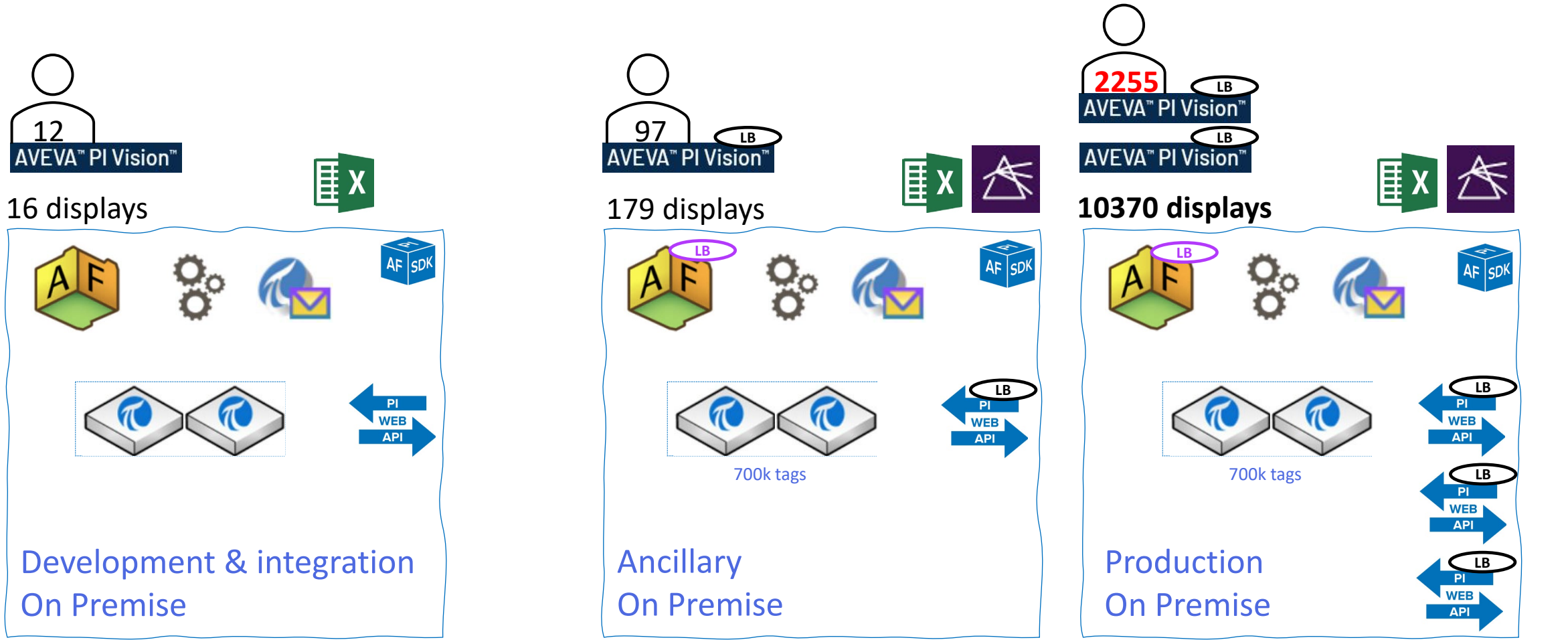
All numbers are in Days		Expected if done manually			-80%	Expected if automated		
		Light	Medium	Heavy		Light	Medium	Heavy
		40	*20*	*20*		*40*	*20*	*20*
	Number of templates	2	6	12		2	6	12
PI Team	Development & testing on Ancillary	**25**	**83**	**100**		**1**	**1**	**3**
	Deployment on ancillary & production	1080	1787	2240		120	140	300
	Totals for the team	***5107***			-4547	***560***		
		3	5	20		3	5	20
Monitoring Community	Development & testing on Ancillary	**20**	**67**	**80**		**3**	**10**	**20**
	Deployment on ancillary & production	920	1433	2000		240	300	800
	Totals for the team	***4353***			-3013	***1340***		

A potential 80% reduction in the time required to deploy models

- This experience convinced us that the time saved could finance the development of a tool around the PI System to help us meet our goals
- Project name : PiUtility

AVEVA Stack at EDF Hydro

220 daily connected users (average)



LB : Actual instances behind a load balancer

LB : Forecasted instances behind a load balancer

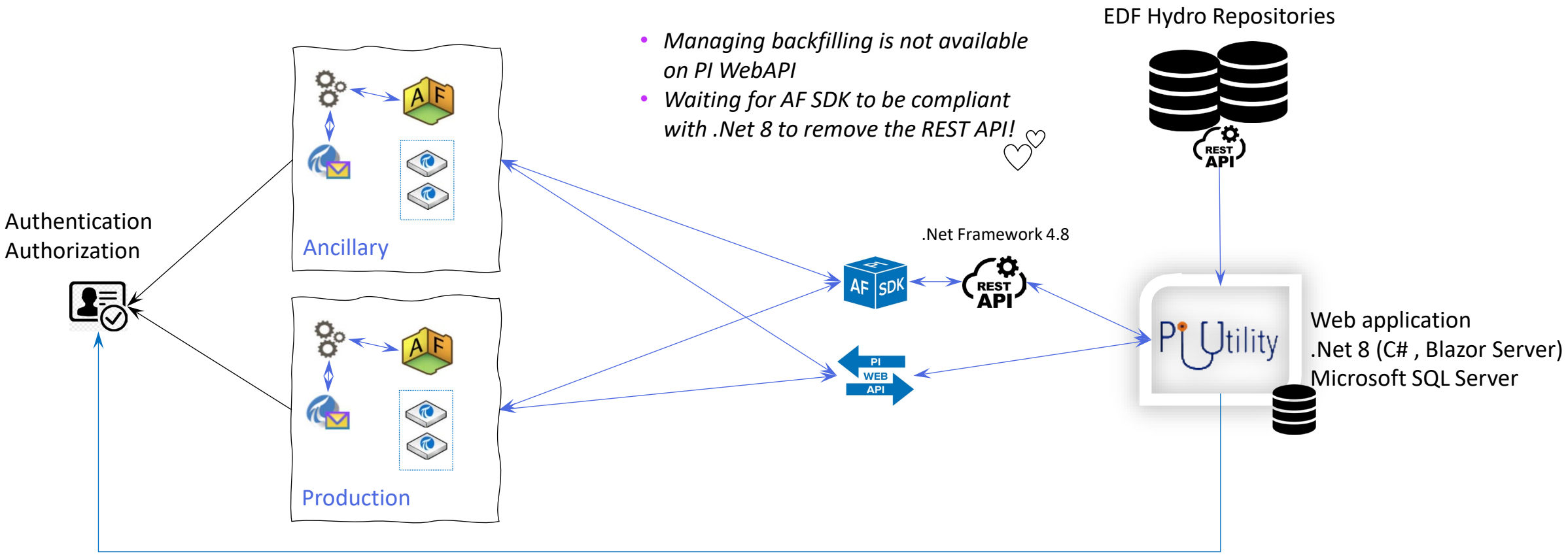
N : Number of users who connected at least once

QUESTION 1

How to minimize the time spent to deploy AF template instances and enable users to do it ?

Technical solution

Using the existing AVEVA stack and EDF Hydro systems



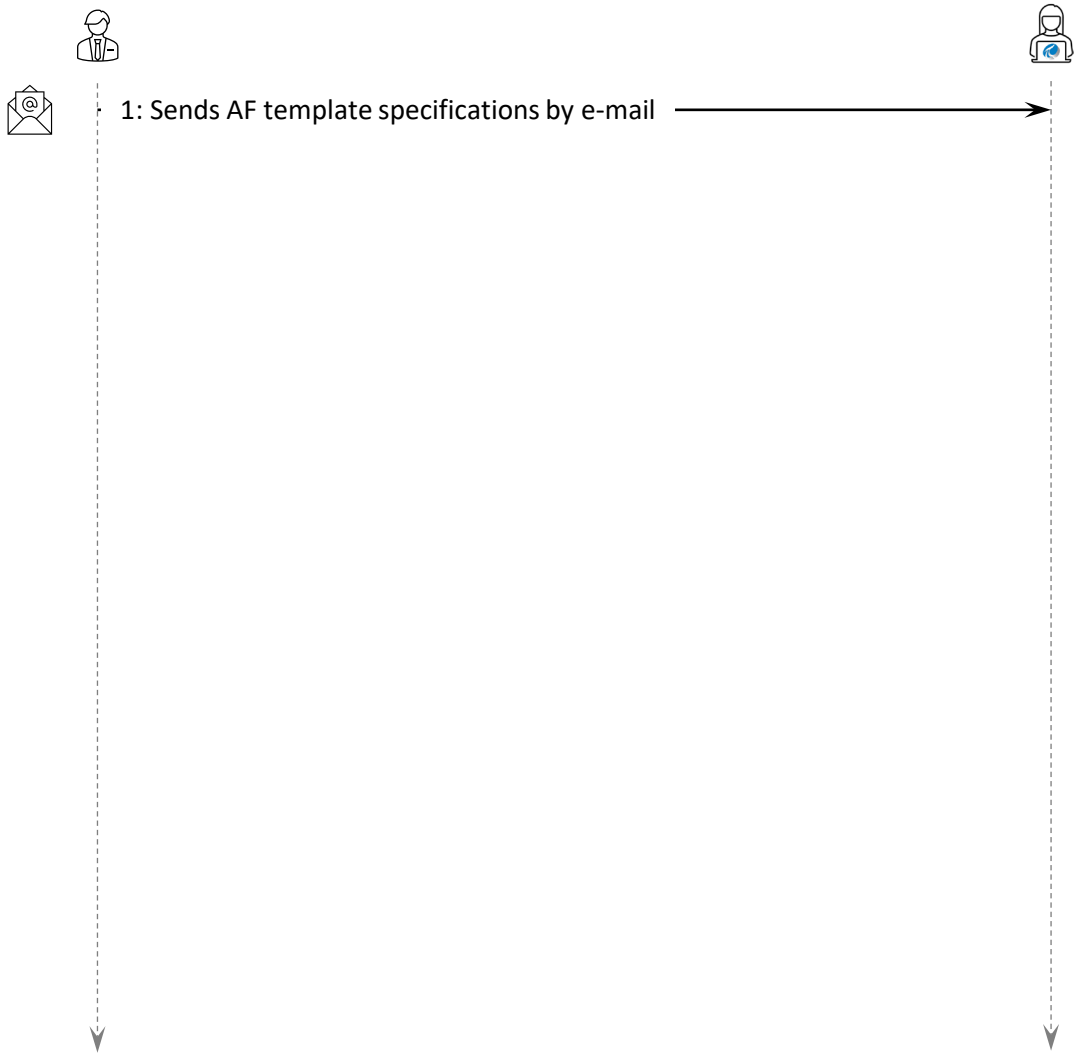
AF Template Creation and Deployment process

- To enhance clarity and storytelling, let me introduce you to :

Estelle : Member of the PI System team

Michael : Member of the Hydro monitoring & performance communities

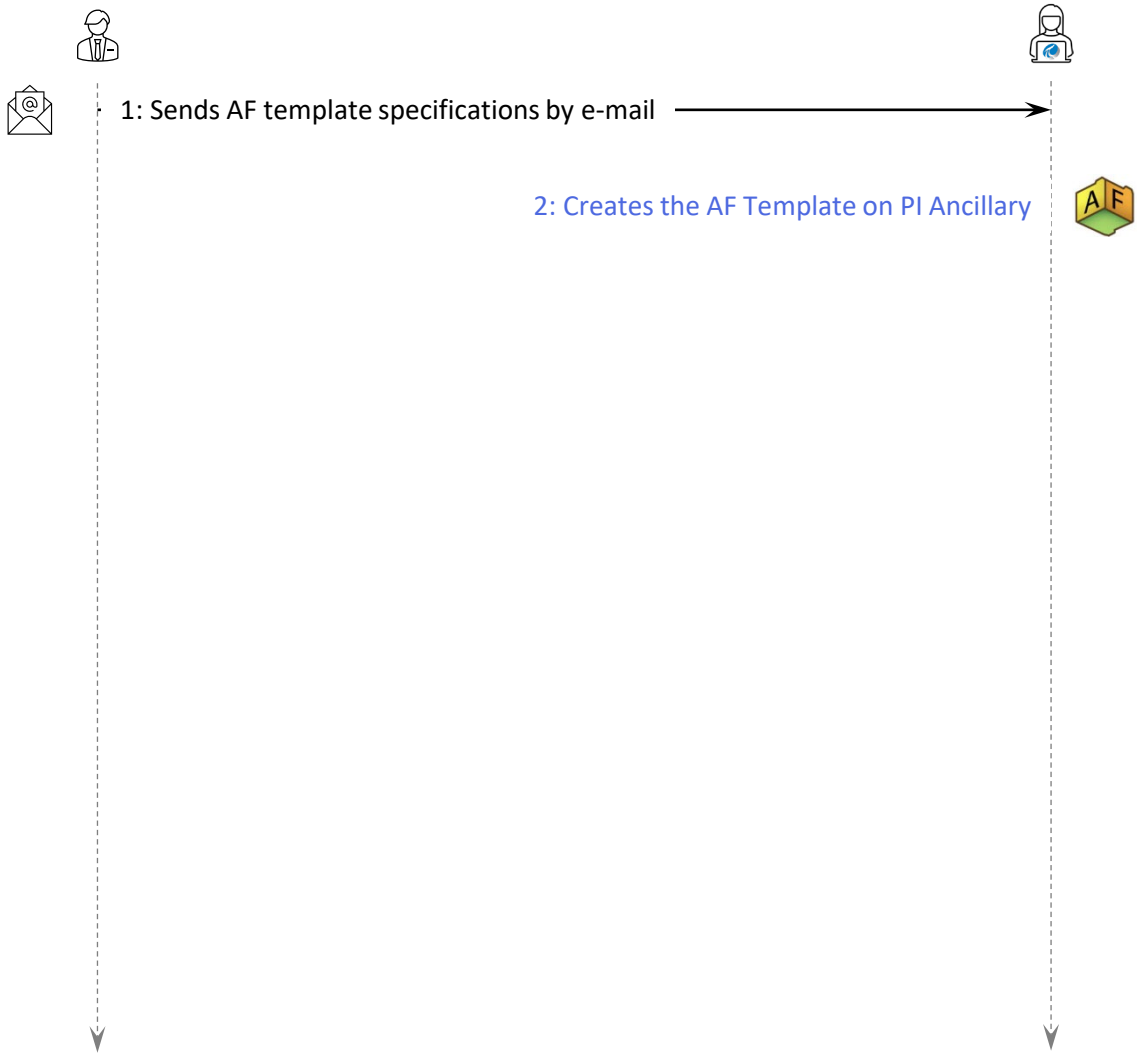
AF Template Creation and Deployment process



Michael sends Estelle a formatted e-mail outlining his requirements.
This need has already been shared and discussed within the monitoring or production communities.

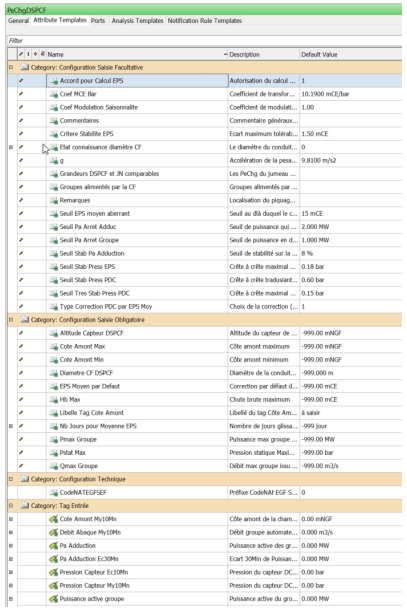
Description *À quoi sert le modèle ?*	
Domaine d'application *À choisir dans la liste suivante (ou proposer un nouveau domaine si la liste existante est incomplète) :* *Alternateur, Calculette, Conduite forcée, Groupe, Jumeau numérique, Notifications, Hydraulicité, Production, Retenue, Services systèmes, Vanne*	
Utilisateurs du modèle *Qui utilisera le modèle ?*	
Généricité *Indiquer si le modèle traite d'un cas d'usage très spécifique ou s'il peut être déployé sur le parc EDF hydro*	
Délai de réalisation souhaité	

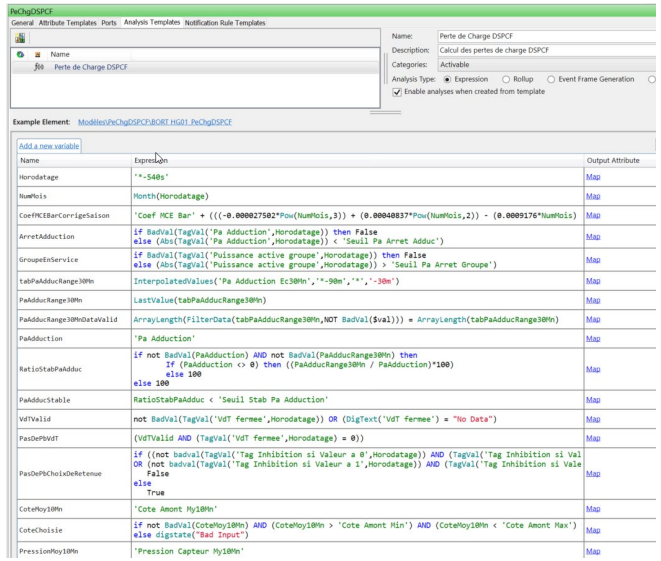
AF Template Creation and Deployment process



Estelle :

- *Selects a **model code***
- *Identifies the **type of Hydro asset associated** with the template (generation unit, transformer, penstock, valve…)*
- ***Creates the AF template** on the Ancillary system*
- *Prepares the **documentation***
- *Develops a **PI Vision display** to assist Michael in testing the template*
- *Conducts the **unit testing***





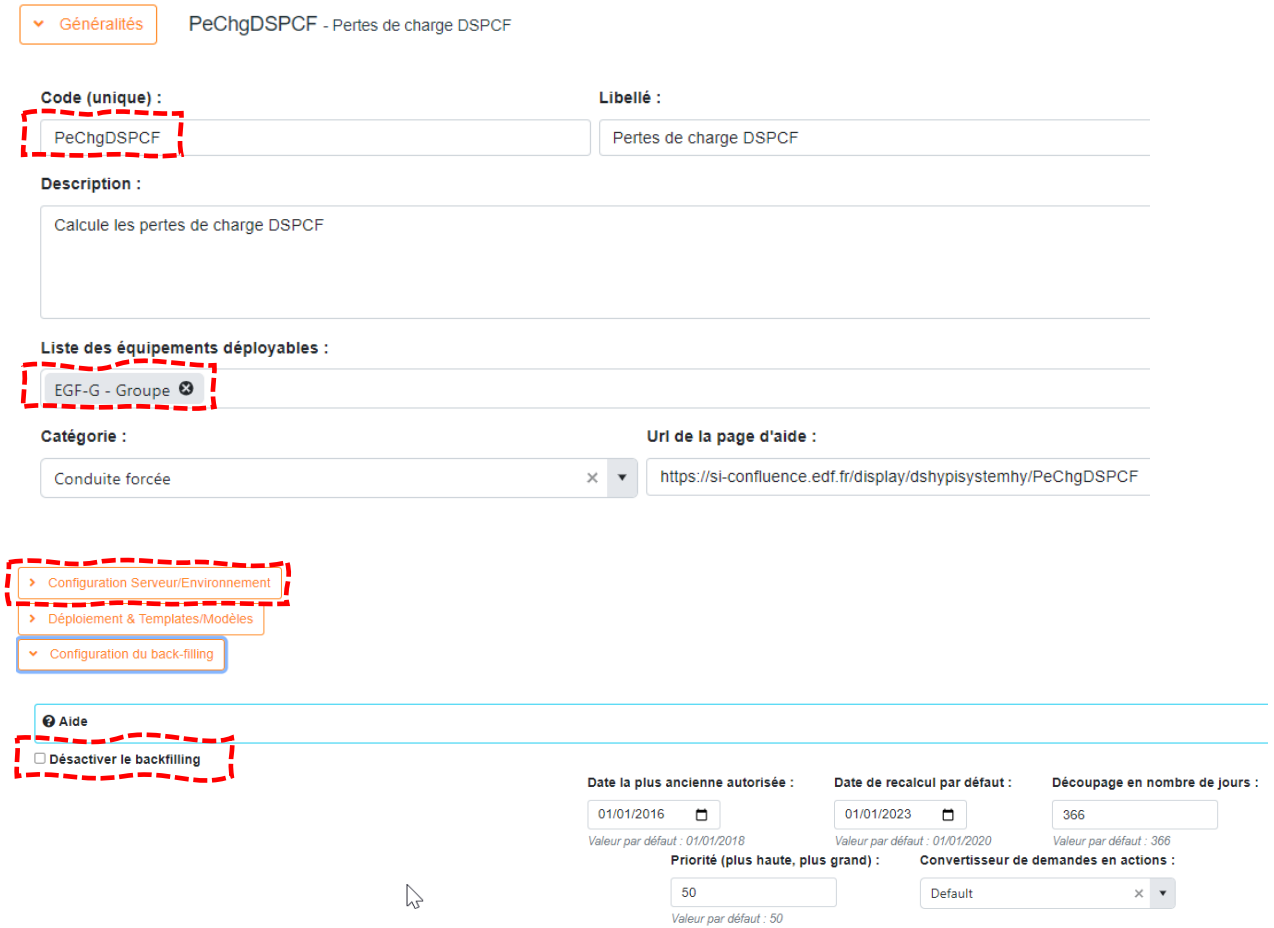
AF Template Creation and Deployment process

1: Sends AF template specifications by e-mail

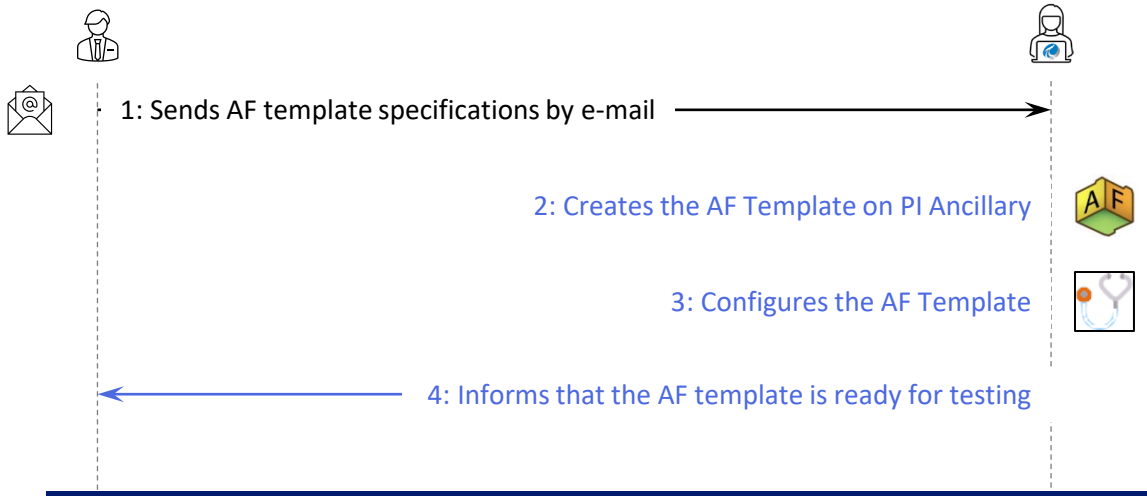
2: Creates the AF Template on PI Ancillary

3: Configures the AF Template

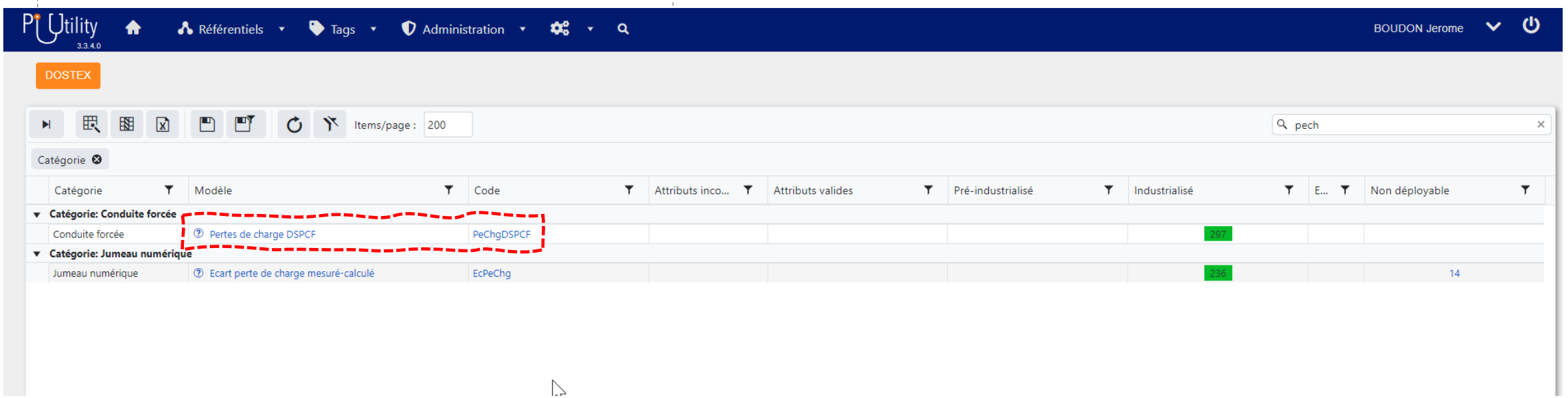
Estelle configures the AF Template in PI Utility.



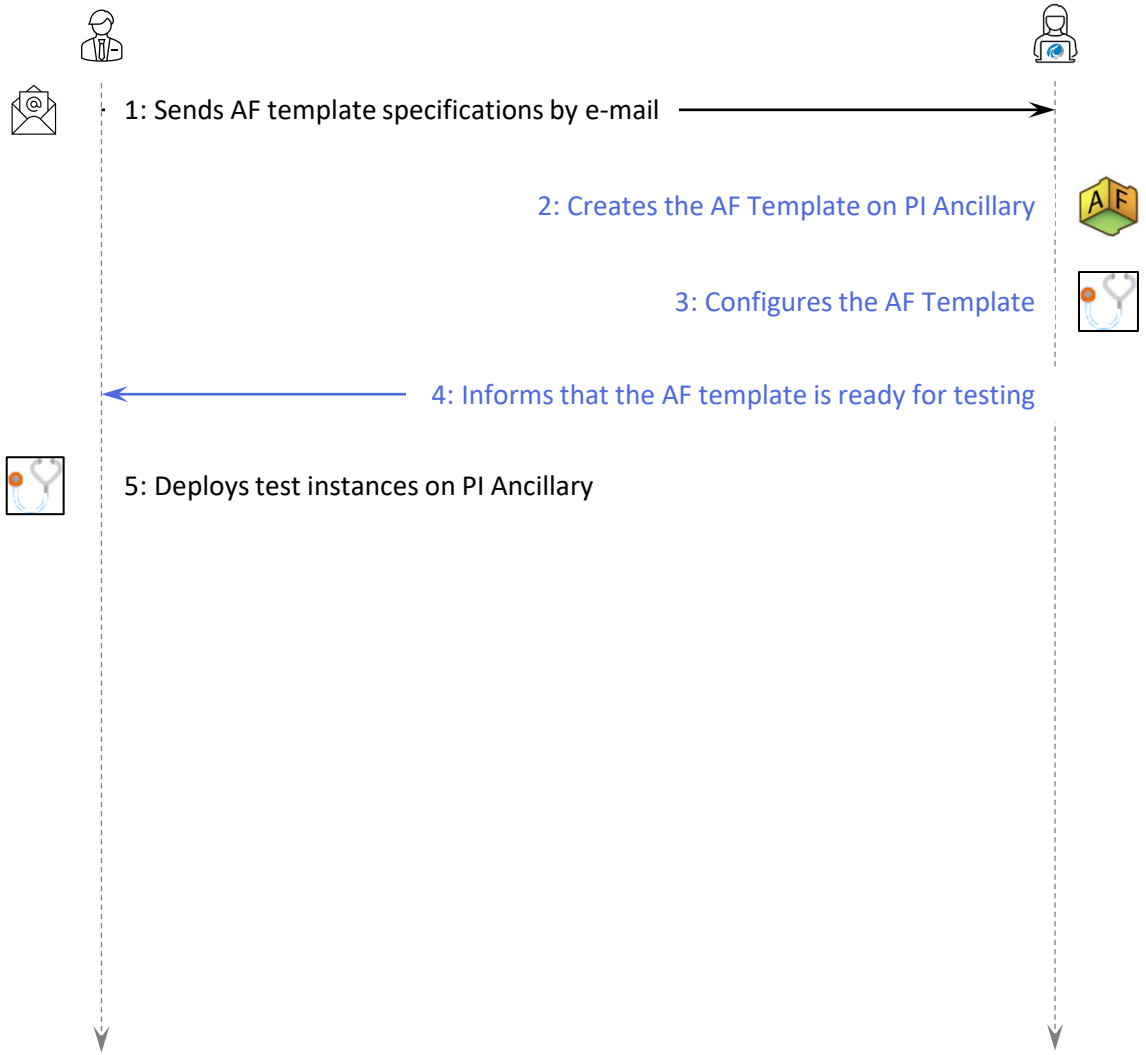
AF Template Creation and Deployment process



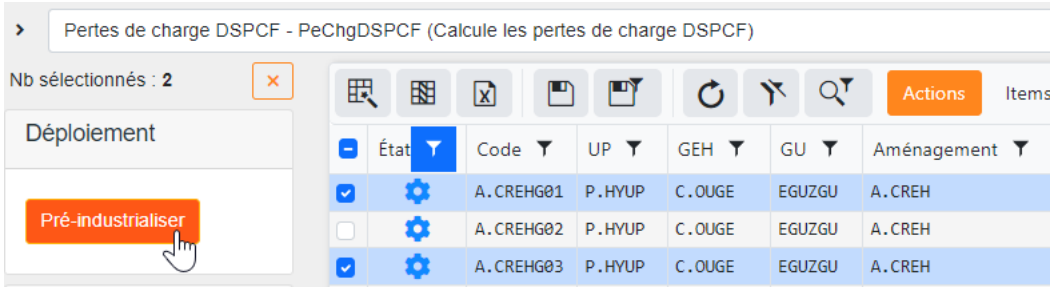
Estelle informs Michael that the AF template is available in PI Utility.



AF Template Creation and Deployment process

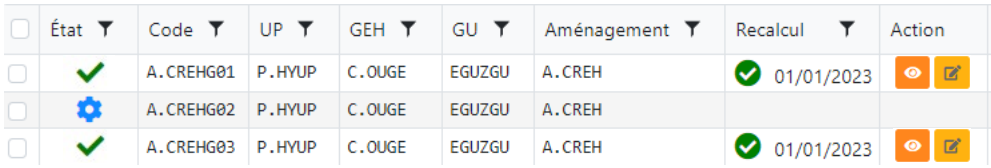


Michael selects the AF Template in PI Utility and chooses the assets to test it.



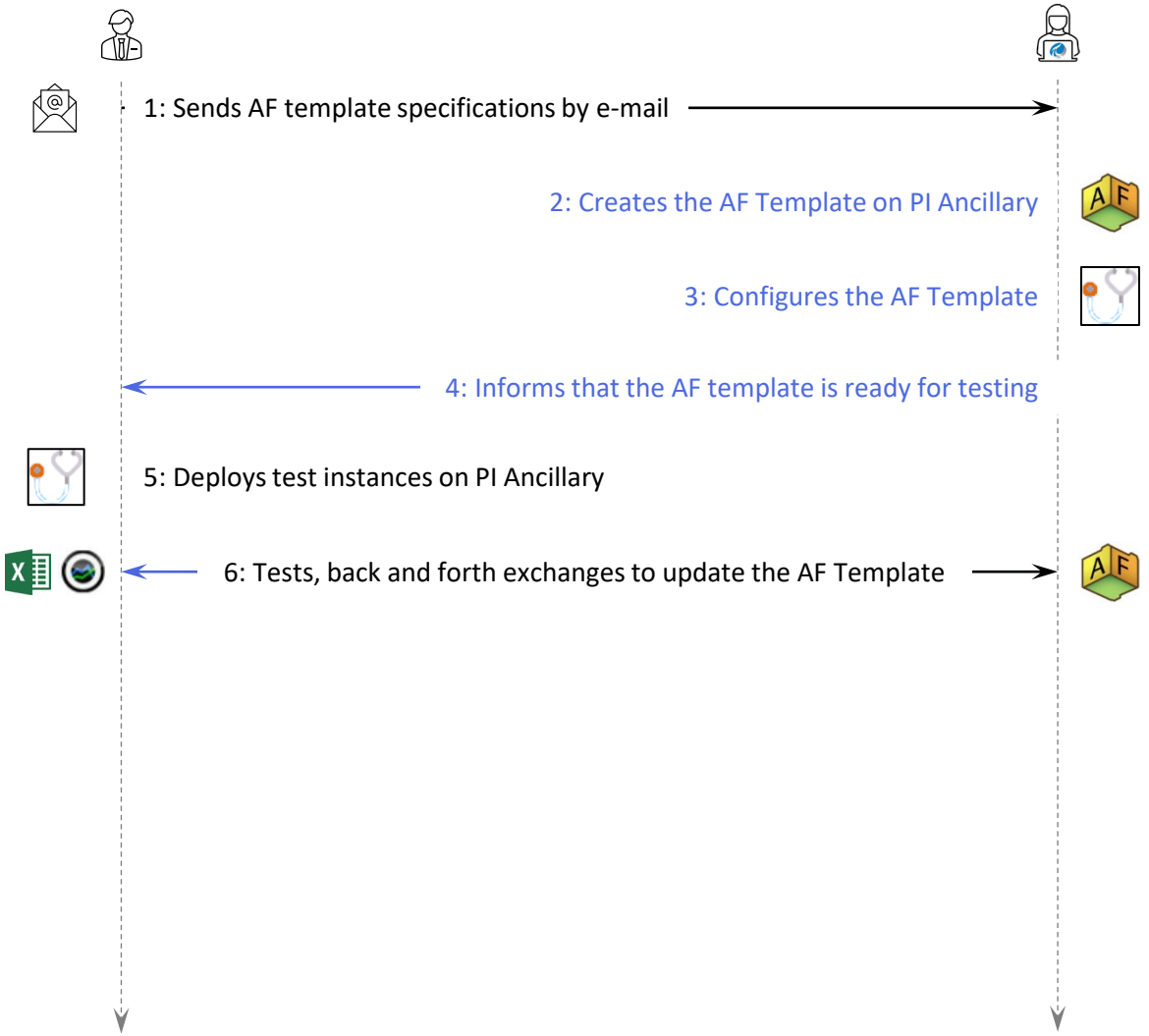
*For each selected asset, PI Utility performs the following actions **on the ancillary PI System** :*

- *Creates the AF Template instance*
- *Maps the input attributes to PI tags (using naming pattern)*
- *Creates the output tags*
- *Starts the analysis*
- *Initiates the backfilling if configured for the template*



The single chevron indicates that the instance is deployed on the ancillary PI System only

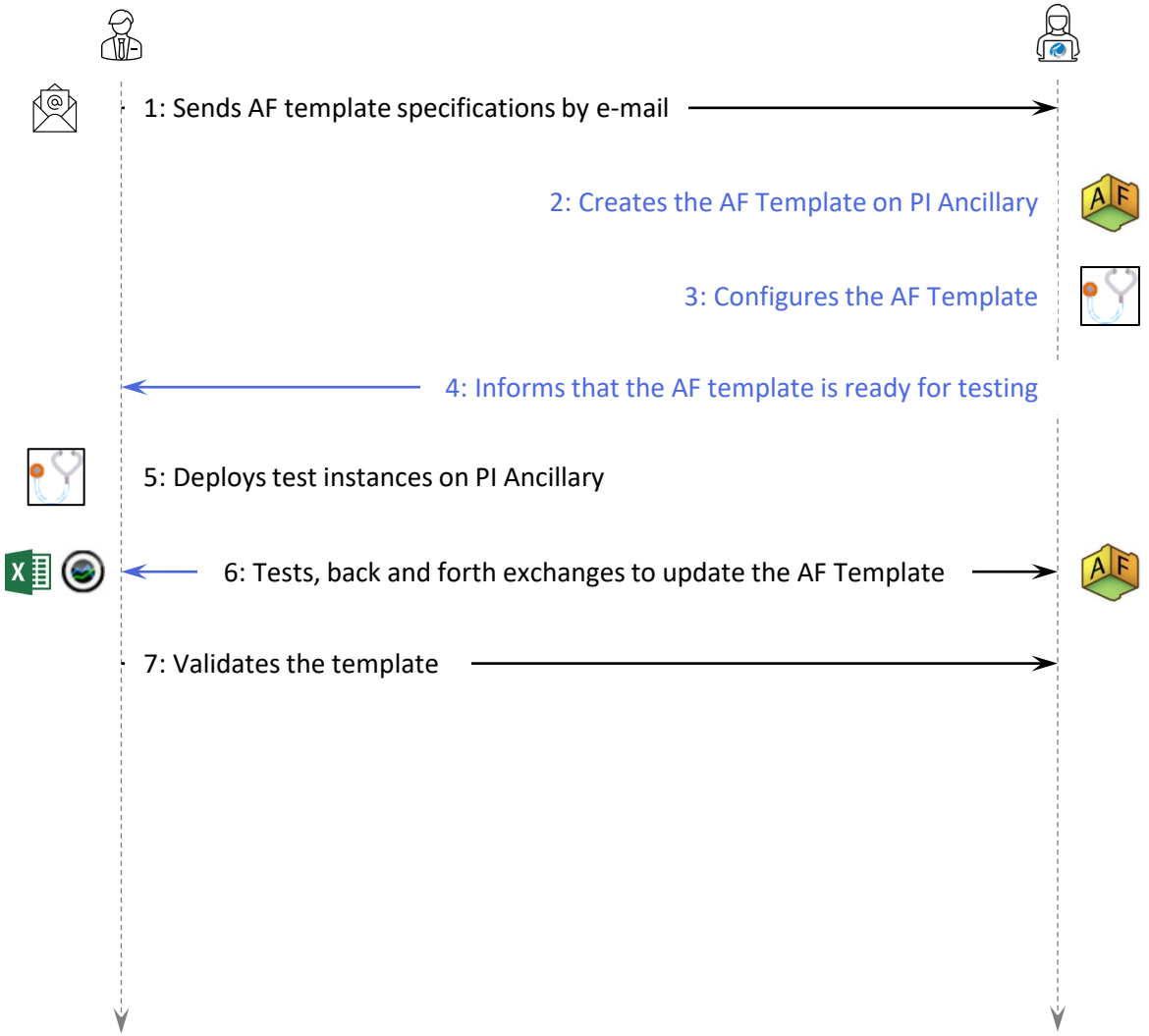
AF Template Creation and Deployment process



Michael uses PI Vision and PI Datalink to test the AF template.

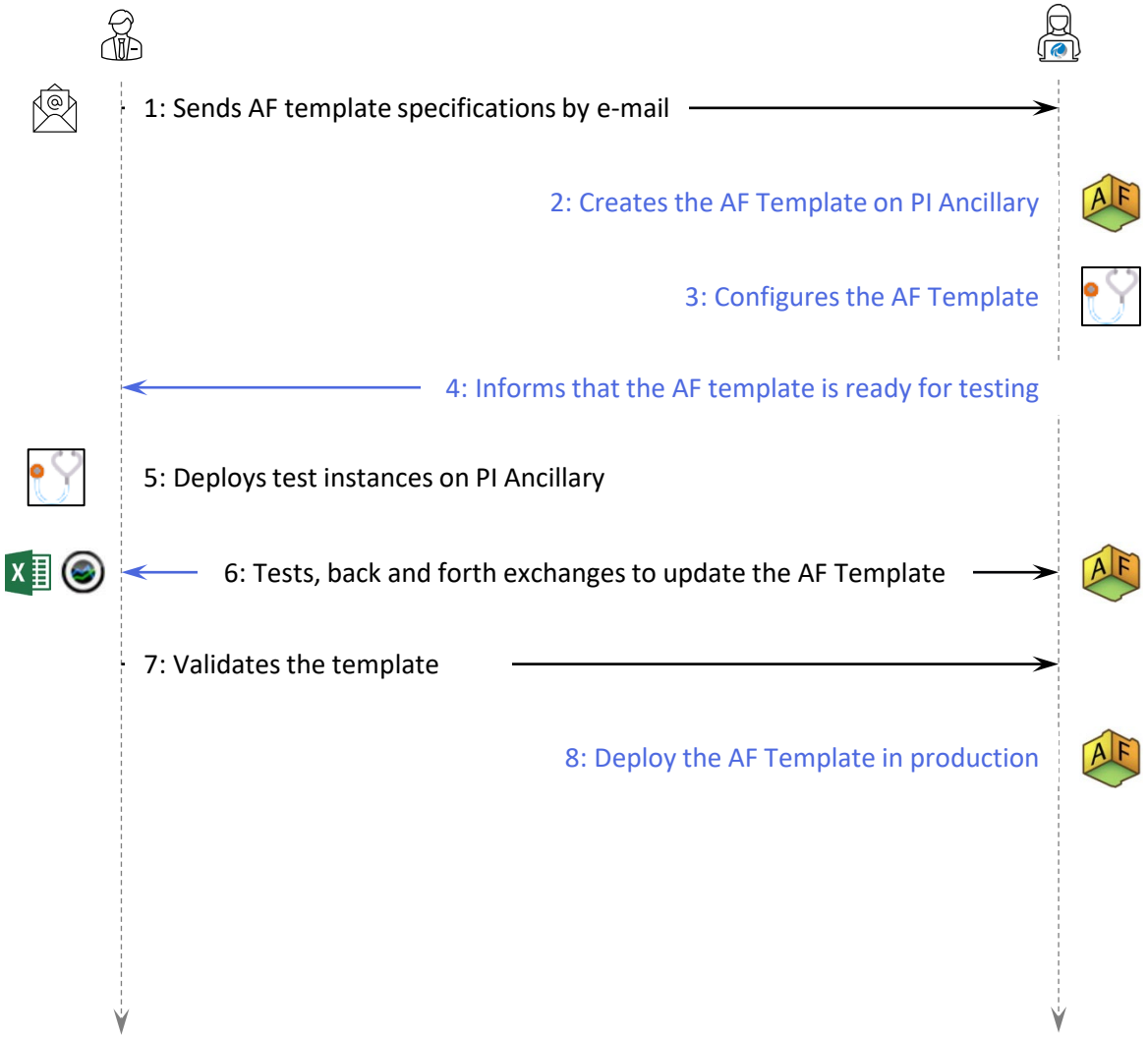
If necessary, Estelle updates the template and Michael continues testing.

AF Template Creation and Deployment process



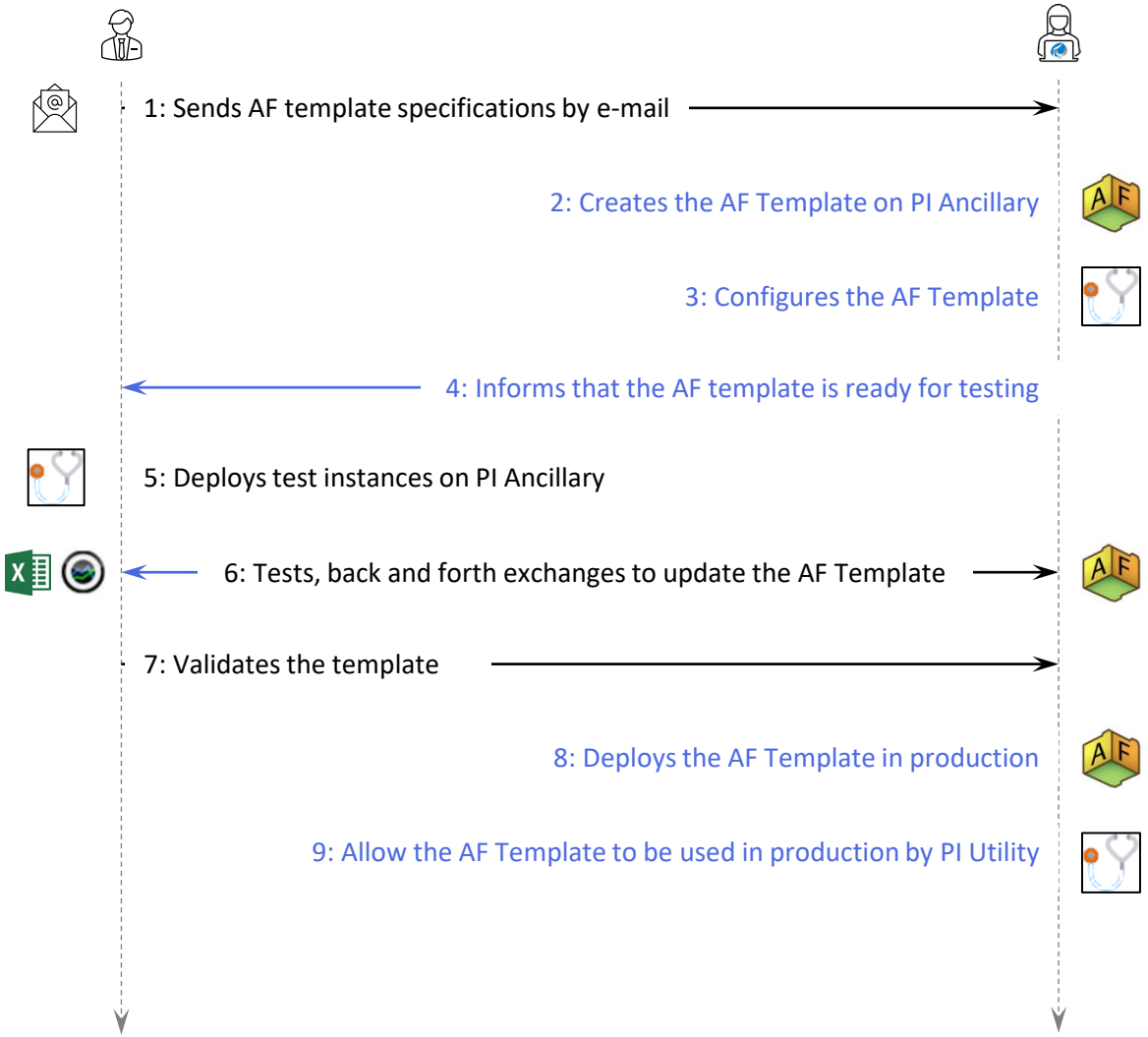
Michael informs Estelle that he validates the AF template.

AF Template Creation and Deployment process

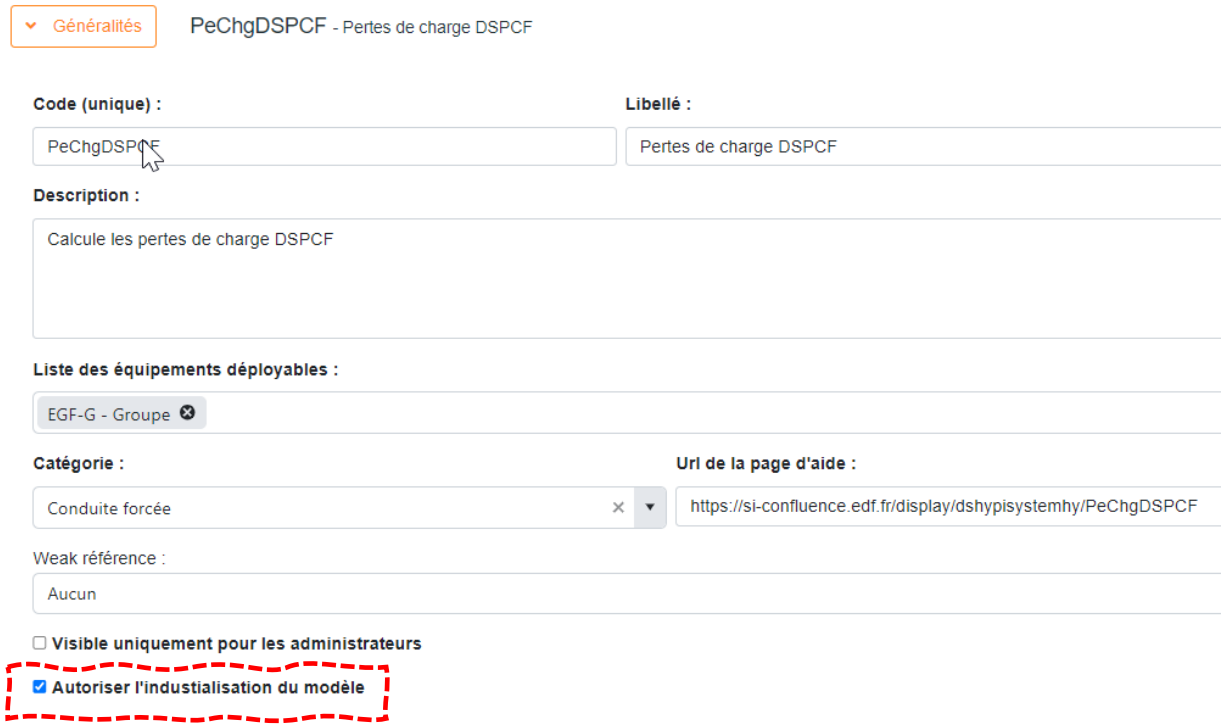


Estelle deploys the AF template to the production environment.

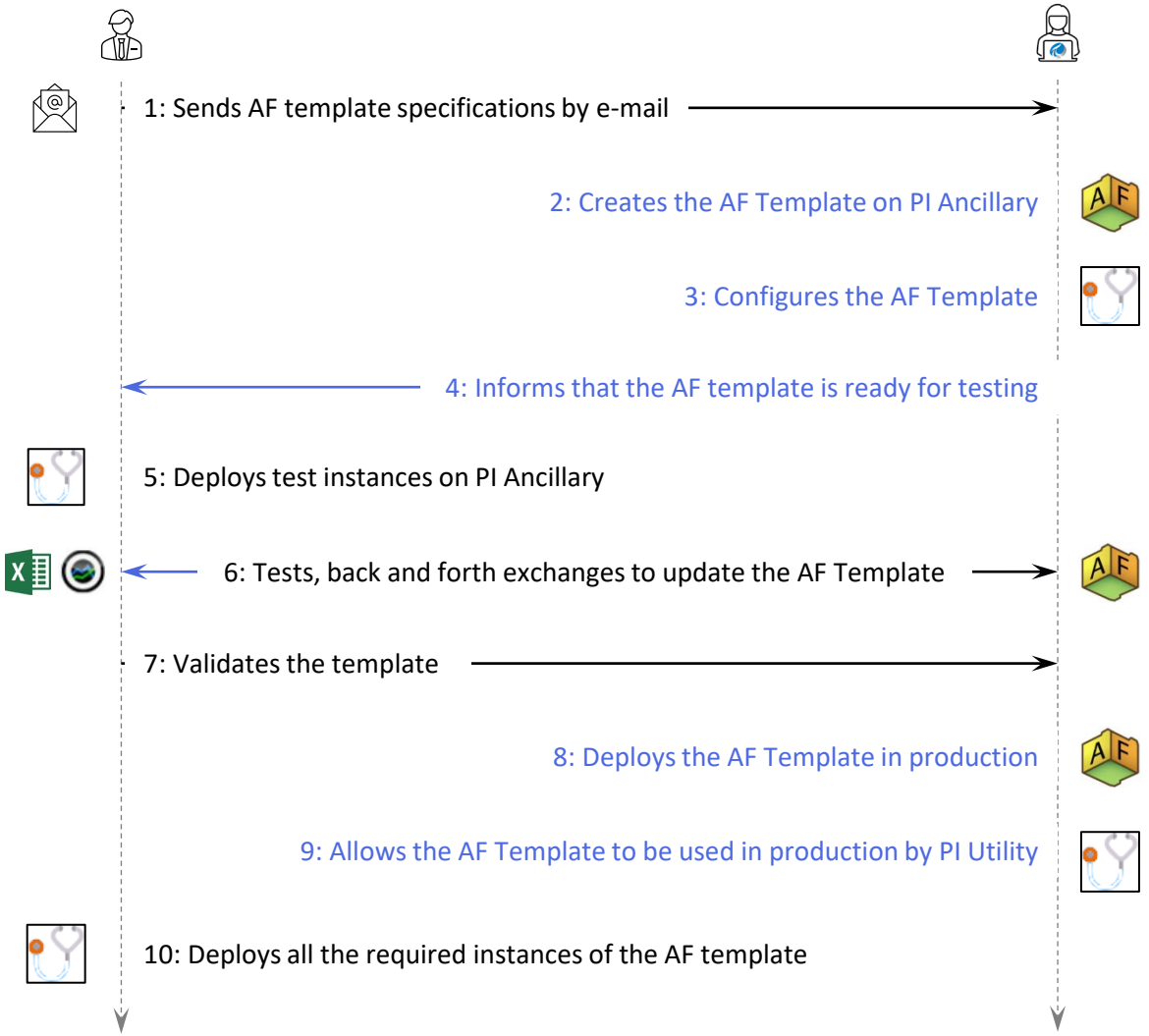
AF Template Creation and Deployment process



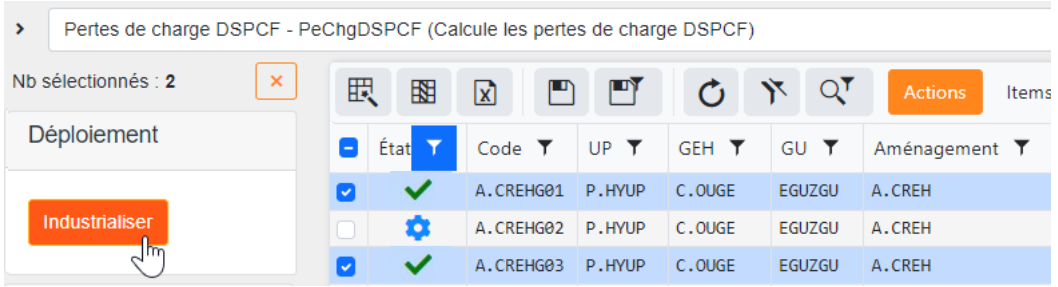
Estelle allows in PI Utility the AF template to be used in production.



AF Template Creation and Deployment process

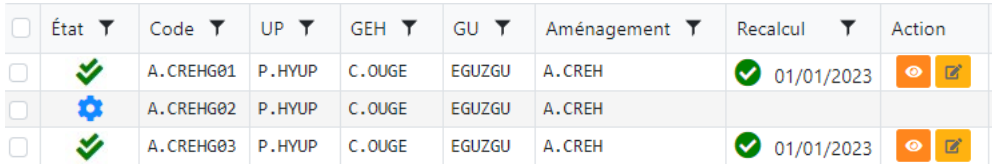


*Michael d*eploys the instances of the AF template to production.



*For each selected asset, PI Utility carries out the following actions in the **PI Production system**:*

- *Creates the AF Template instance*
- ***Copies the attributes configuration** from the ancillary instance*
- *Generates the output tags*
- *Starts the analysis*
- *Initiates the backfilling if configured*



The double chevron indicates that the instance is deployed on both the ancillary AND production systems with the same settings

Dashboard that allows to monitor all the deployed instances and their statuses

Incomplete settings

Deployed on ancillary only

Deployed on ancillary AND production

Assets excluded from the template

Instances in error

Items/page : 200

Rechercher...

Catégorie

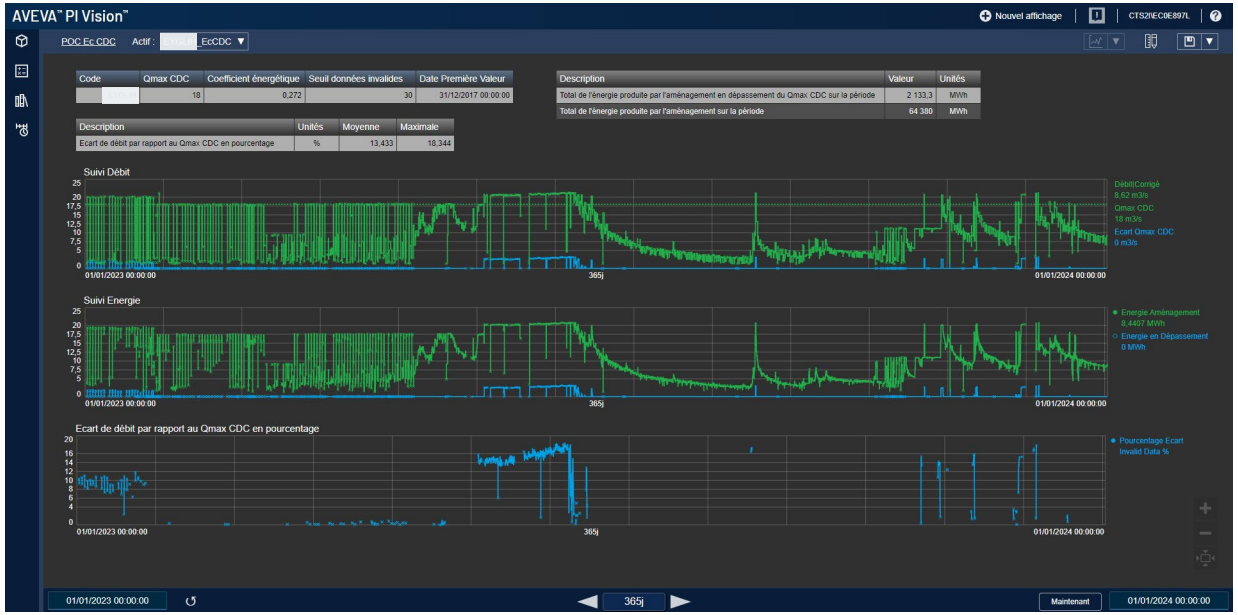
Catégorie	Modèle	Code	Attributs inco...	Attributs valides	Pré-industrialisé	Industrialisé	E...	Non déployable
Calculette	Translation et écrêtement	TrlEcr	3		2	3		
Catégorie: Conduite forcée								
Conduite forcée	Pertes de charge DSPCF	PeChgDSPCF				297		
Catégorie: Création de tags								
Catégorie: Durée								
Durée	Durée à un état depuis une date	DurEtat	1		4	20		
Durée	Temps de freinage	TpFr	3		30			
Durée	Temps de fonctionnement	TpsFct			1	1102		29
Durée	Temps de fonctionnements avec conditions paramétrables	TpsFct Condition	33	2	13	1		
Durée	Temps de fonctionnement entre 2 conditions sur donnée A	TpsFct2Cdi	2		71	207		10
Durée	Déprécié - Temps de fonctionnement entre 2 TOR (ne plus	TpsFct2Tor	8	1	31	151		10
Catégorie: Ecart								
Ecart	Ecart 10 Min	Ec10Mn	1			290		4
Ecart	Ecart entre deux valeurs	Ec2Val			1	7		
Ecart	Ecart 30 Min	Ec30Mn	4			290		2
Catégorie: Gradient								
Gradient	Gradient évènementiel conditionné	GdEvtCd	1		59	34		2
Gradient	Gradient périodique conditionné	GdPrdCd	2			17		2
Gradient	Gradient périodique sur valeurs moyennées	GdPrdValMy	1		6	31		
Catégorie: Groupe								
Groupe	Estimation de la prochaine visite de roue (POC)	EstViRo	23		16			
Groupe	Estimation de la prochaine visite de roue	EstViRoTeqPmax				9		
Groupe	Intensité de phase	IPh			5			
Groupe	Puissance groupe indispo	PaGpIdp				31		
Groupe	Puissance apparente	Pap				525		15
Groupe	Séquence d'arrêt en compensateur synchrone	SqArtCp	2		11	49	1	270
Groupe	Séquence d'arrêt en pompe	SqArtPp				34		1
Groupe	Séquence d'arrêt en turbine	SqArtTb	42	30	31	483		175

1

Afficher les éléments 1 - 159 de 159

Deviation from the flowrate specifications

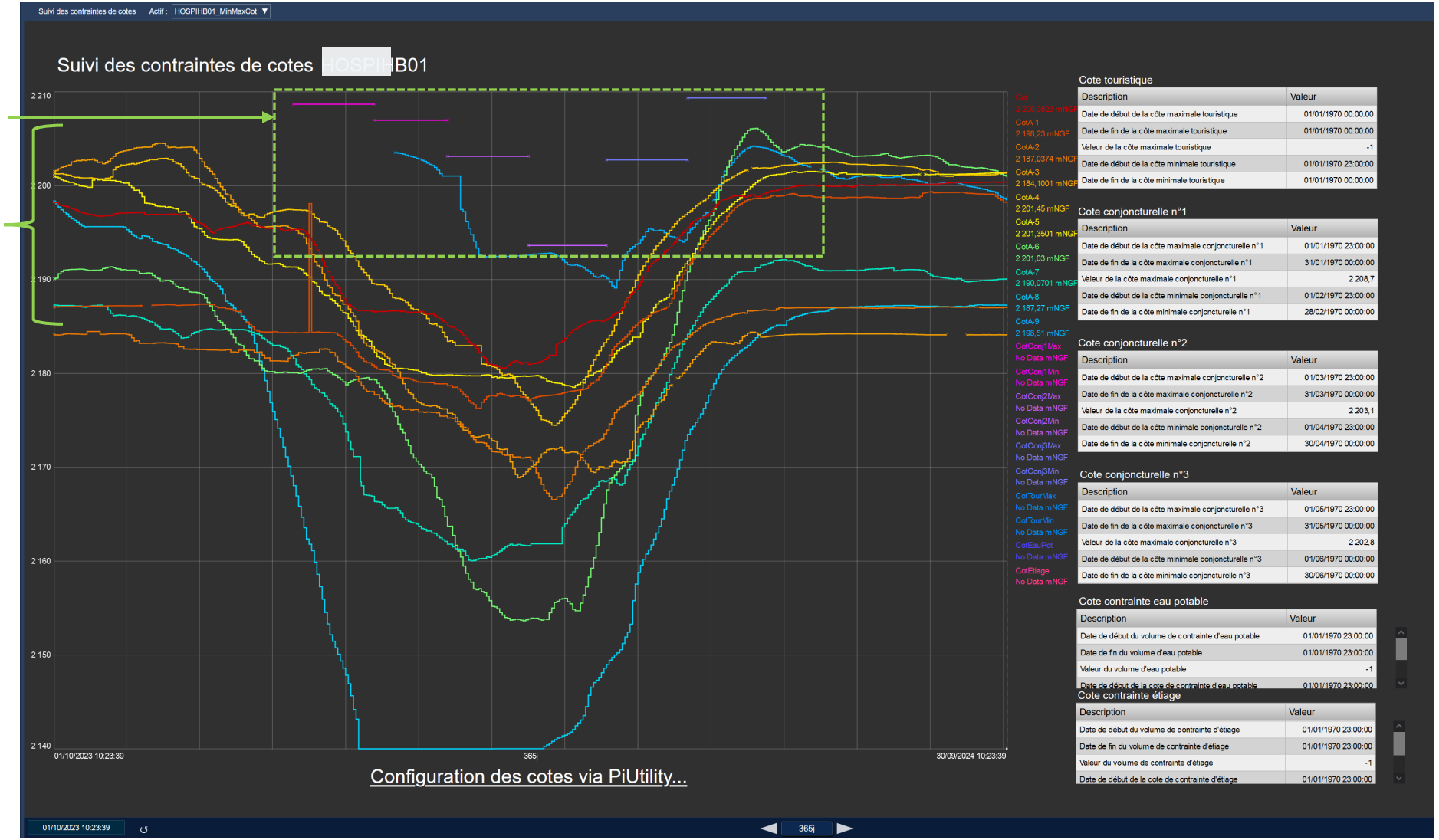
- *Classification*
  - **Light**
- *Objectives*
  - Calculation of the power produced by a plant when the downstream flow exceeds the specifications related to the concession.
- *Time to build and test*
  - 2 days
- *Time to deploy*
  - 2 days (40 power plants)
- *Earnings*
  - Several hours saved per power plant
  - Quality and precision of the results



	A	B	C	D	E
1	Aménagement	\\GREPS00SI04UX05\METIERS\Modèles\ EYGLIH_EcCDC			
2	Tag PI	Débit	\\DPIH-His EYGLIHS01CC01mDbtTotCalcJN	Débit Moy10Mn aménagement calculé Optimiz via puissance&cotes PI	
3	Année	Moyenne Pourcentage Ecart Qmax CDC (%)	Maximum Pourcentage Ecart Qmax CDC (%)	Total Energie en Dépassement (MWh)	Total Energie Aménagement (MWh)
4	01/01/2015 - 01/01/2016	[-11057] Not Enough Values For Calculation	[-11057] Not Enough Values For Calculation	[-11057] Not Enough Values For Calculation	[-11057] Not Enough Values For Calculation
5	01/01/2016 - 01/01/2017	[-11059] No Good Data For Calculation	[-11059] No Good Data For Calculation	[-11059] No Good Data For Calculation	[-11059] No Good Data For Calculation
6	01/01/2017 - 01/01/2018	[-11059] No Good Data For Calculation	[-11059] No Good Data For Calculation	[-11059] No Good Data For Calculation	[-11059] No Good Data For Calculation
7	01/01/2018 - 01/01/2019	13,7	16,3	2216	25984
8	01/01/2019 - 01/01/2020	13,7	20,0	2467	44981
9	01/01/2020 - 01/01/2021	14,3	20,0	4758	79181
10	01/01/2021 - 01/01/2022	12,4	15,2	2021	55800
11	01/01/2022 - 01/01/2023	10,3	14,3	919	27955
12	01/01/2023 - 01/01/2024	13,4	18,3	2133	64371
13					
14					

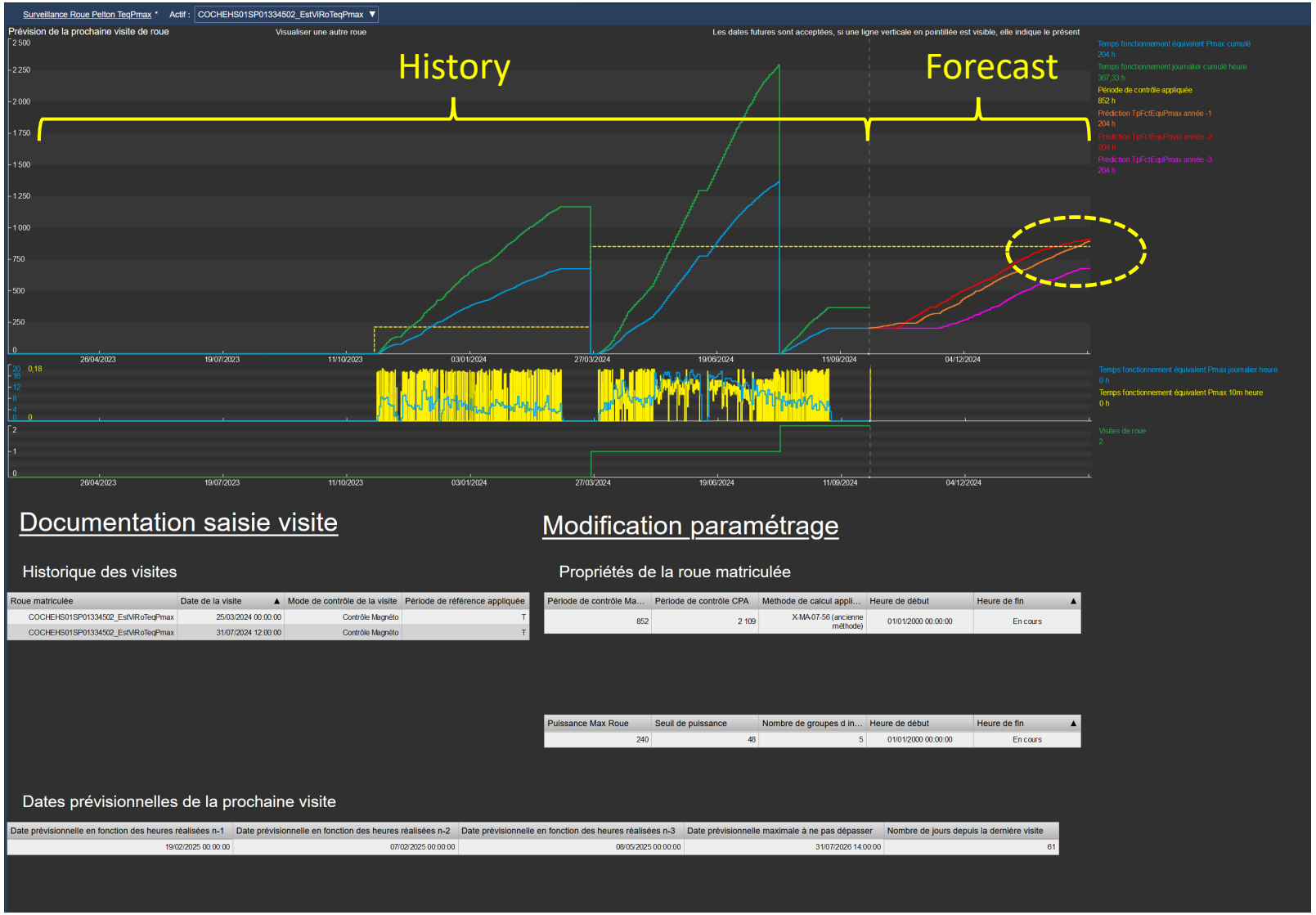
Monitoring of reservoir elevation constraints

- *Classification*
  - **Medium**
- *Objectives*
  - Definition of up to 7 elevation constraints (Contextual levels, low water level, tourist levels, drinking water…)
  - Overlay of the reservoir level over the last ten years
- *Time to build and test*
  - 4 days
- *Time to deploy*
  - 5 days (100 reservoirs)
- *Earnings*
  - Instant visualization of reservoir history
  - Real-time monitoring of compliance with the reservoir level constraints



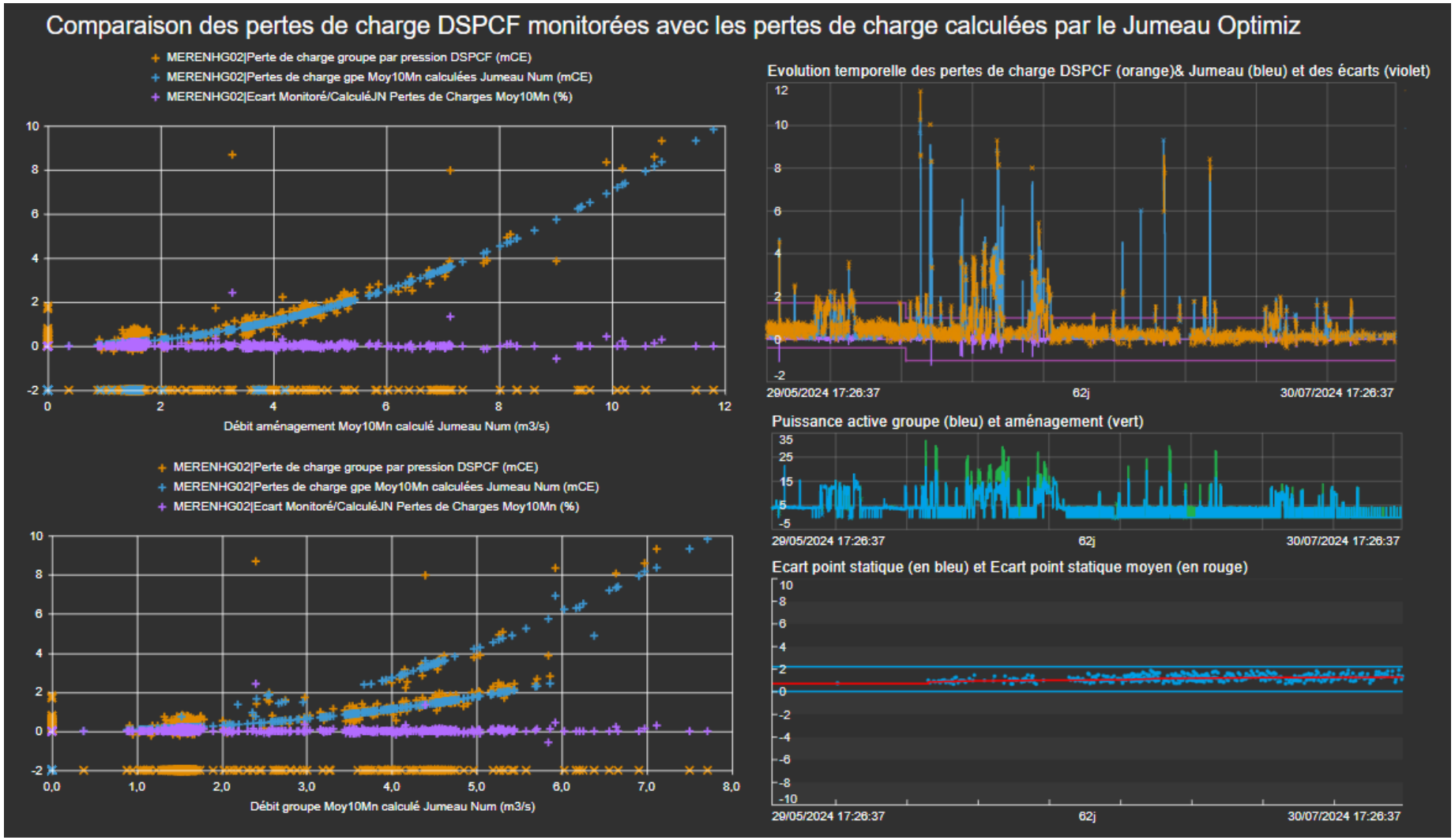
Estimated date of the next Pelton wheel inspection

- *Classification*
  - **Heavy**
- *Objectives*
  - Automatic calculation of the next Pelton wheel inspection, considering the history, the operation of the wheel and its load, and the EDF Hydro reference document on wheel monitoring
  - Uses the past 3 years history to forecast 3 possible dates
  - Will be done on ~300 wheels at the target
- *Time to build and test*
  - 13 days on AF + 30 on PI Utility
- *Time to deploy*
  - Deployment in progress
  - 20-30 days (at the target)
- *Earnings*
  - Assistance in scheduling the wheel inspection at the most appropriate time (economically and according to production constraints)
  - Days of work per wheel



Head losses monitoring

- *Classification*
  - **Heavy**
- *Objectives*
  - Comparison of measured head losses with those calculated by the digital twin
- *Time to build and test*
  - 6 days
- *Time to deploy*
  - 50 days (297 generation units)
  - Mainly spent searching for the exact values of the model's static attributes
- *Earnings*
  - Knowing the head losses of all the galleries, penstocks and the net heads
  - Improving the quality of the energy models of our installations in the digital twin that are used for the calculation of the Hydro power plant's programs
  - Detecting abnormal head losses and problems in turbines



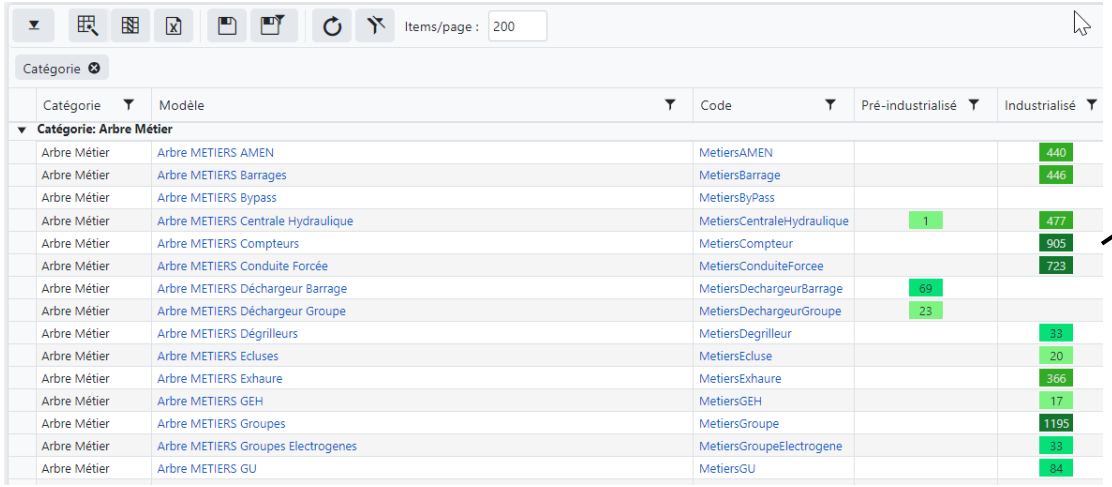
Example of comparison between monitored data and data calculated by the digital twin

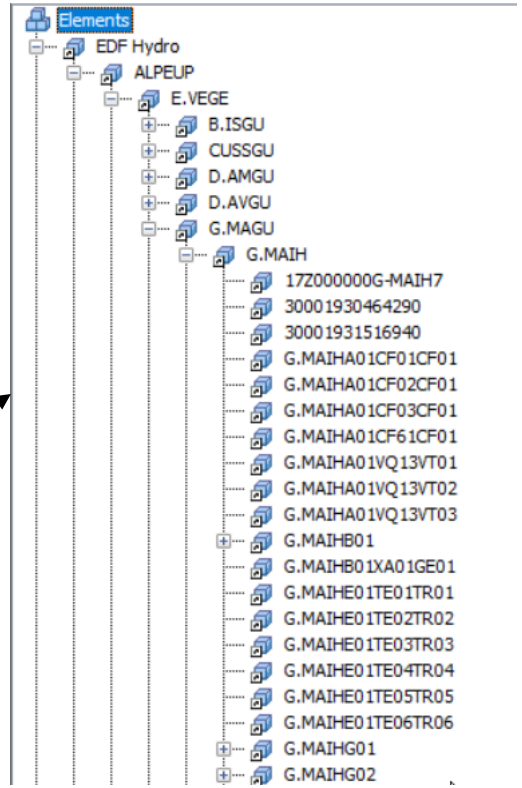
QUESTION 2

How to automatically generate AF hierarchies from the company’s asset repositories ?

Automatically generate AF hierarchies from the company's asset repositories

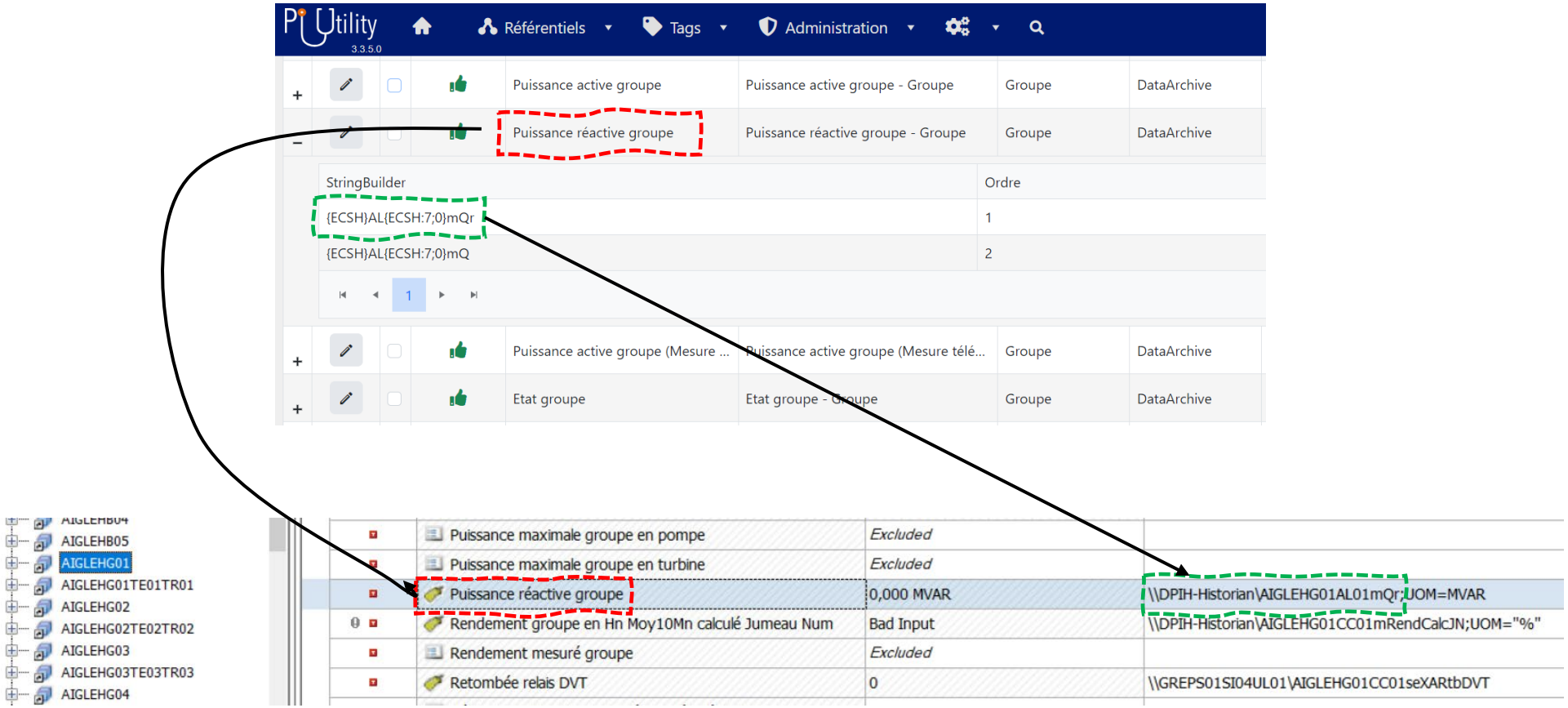
- Deploying **AF elements to represent assets** is technically like deploying **AF elements to perform calculations**, so the same mechanism could be applied
- We just had to create
  - One **AF template per asset type** (generation unit, dam, transformer, penstock, valve…)
  - One **AF template per organization entity** (Production Unit, Group of power plant, power plant)
- Configure these templates in PI Utility





Automatically generate AF hierarchies from the company's asset repositories

- Create a **mechanism to map AF attributes to PI tags** using naming patterns and exceptions

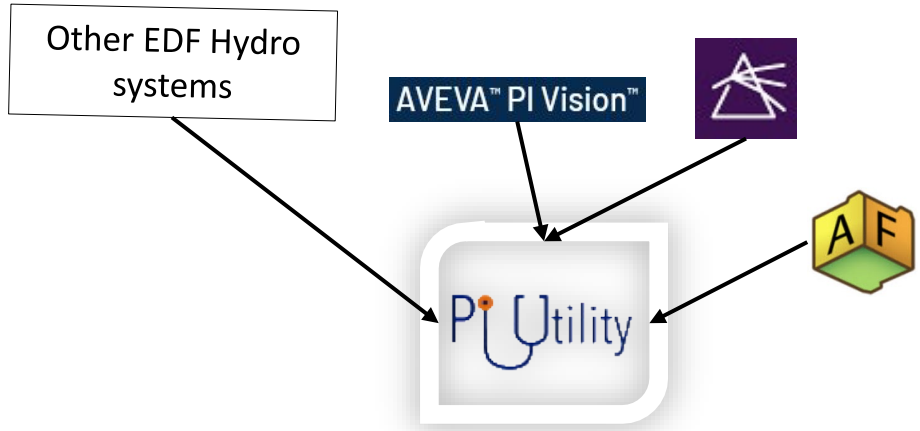


QUESTION 3

How to extend PI System features ?

PI tags usage

- Tag usages are collected from various sources :
  - PI AF, PI Vision, Predictive Analytics and few EDF Hydro systems
- Provide insights on where these PI tags are used
- With tag additional information
  - First and last value timestamp, tag frequency



PiUtility 3.4.1.0 | Référentiels | Tags | Administration

Usage des tags :

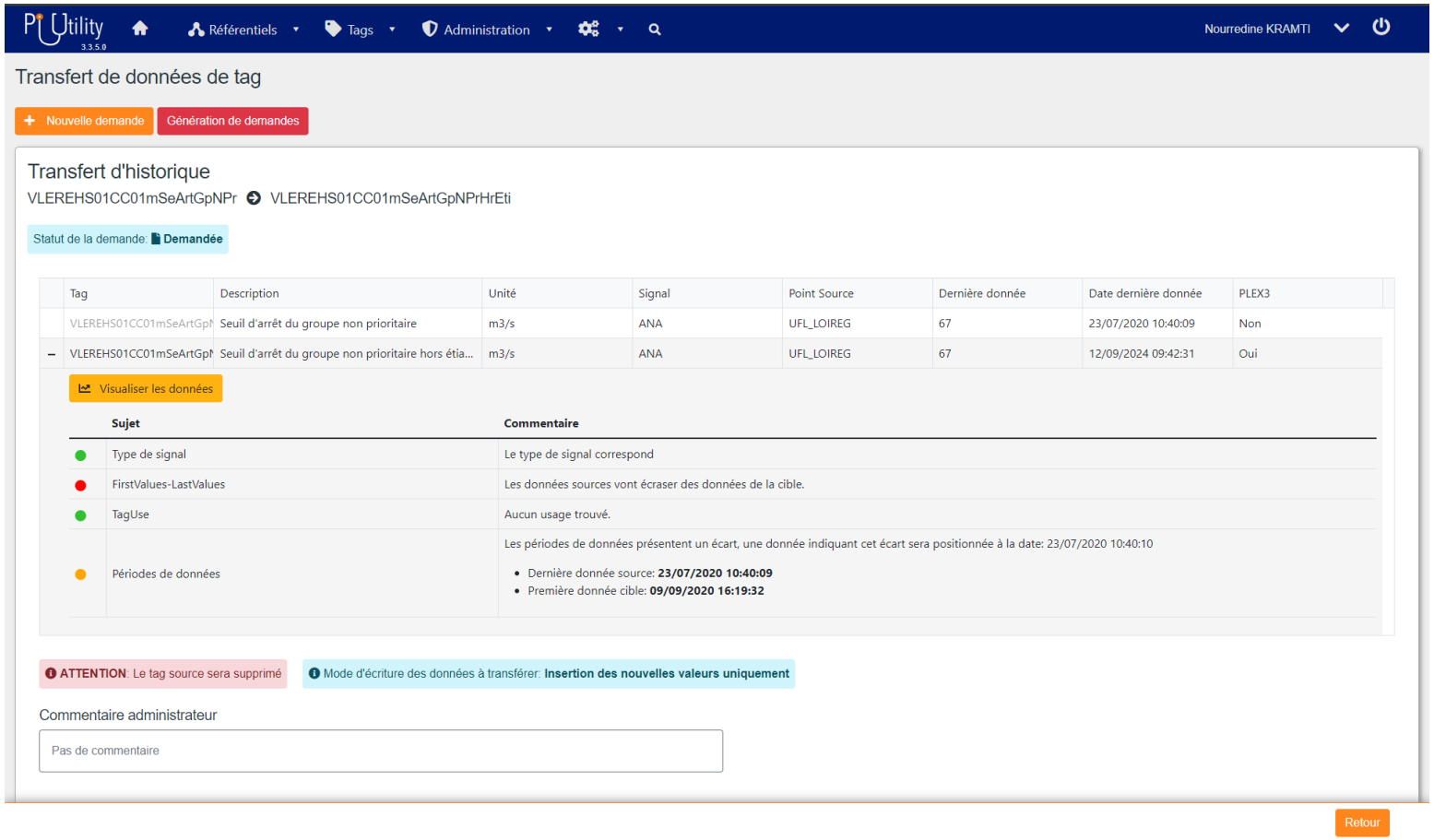
Ne visualiser que les tags sans usage :

Items/page : 50

Enviro...	Data Serveur	Tag	Source	Chemin	Usage	Info. supp.	Vérification	Date dernière valeur
Prod		G.MAIHG01AL01mPa	Prex		PuissanceBrute|G_MA	Ecart Puissance active brute / atten...	01/10/24 15:06	11/09/2024 10:13:16
Prod	DPIH-Historian	G.MAIHG01AL01mPa	PiUtility	\\GREPS00SI04UX05\DPIH\EDF\DPIH\UNITE ALPES\GEH ECRINS VERCORS\GU GRAND-MAISON\GRAND-MAISON\G.MAI...	PortailPS	Portail P&S	01/10/24 23:55	11/09/2024 10:13:16
Prod	DPIH-Historian	G.MAIHG01AL01mPa	PiUtility	\\GREPS00SI04UX05\METIERS\Modèles\Pap\G.MAIHG01_Pap|Puissance active groupe	Pap	Puissance apparente	01/10/24 23:55	11/09/2024 10:13:16
Prod	DPIH-Historian	G.MAIHG01AL01mPa	PiUtility	\\GREPS00SI04UX05\METIERS\Référentiels\Equipements\G.MAIHG01|Puissance active groupe	MetiersGroupe	Arbre METIERS Groupes	01/10/24 23:55	11/09/2024 10:13:16
Prod	DPIH-Historian	G.MAIHG01AL01mPa	PiUtility	\\GREPS00SI04UX05\METIERS\Référentiels\Equipements\G.MAIHG01GU01|Puissance active groupe	MetiersGroupe	Arbre METIERS Groupes	01/10/24 23:55	11/09/2024 10:13:16
Prod	DPIH-Historian	G.MAIHG01AL01mPa	PiUtility	\\GREPS00SI04UX05\METIERS\Référentiels\Equipements\G.MAIHG01GU01PA07|Puissance active groupe	MetiersGroupe	Arbre METIERS Groupes	01/10/24 23:55	11/09/2024 10:13:16
Prod	DPIH-Historian	G.MAIHG01AL01mPa	PiUtility	\\GREPS00SI04UX05\METIERS\Référentiels\Equipements\G.MAIHG01GU01PA08|Puissance active groupe	MetiersGroupe	Arbre METIERS Groupes	01/10/24 23:55	11/09/2024 10:13:16
Prod	DPIH-Historian	G.MAIHG01AL01mPa	PiUtility	\\GREPS00SI04UX05\METIERS\Référentiels\Equipements\G.MAIHG01GU01PA10|Puissance active groupe	MetiersGroupe	Arbre METIERS Groupes	01/10/24 23:55	11/09/2024 10:13:16
Prod	DPIH-Historian	G.MAIHG01AL01mPa	PiUtility	\\GREPS00SI04UX05\METIERS\Référentiels\Equipements\G.MAIHG01GU01PA11|Puissance active groupe	MetiersGroupe	Arbre METIERS Groupes	01/10/24 23:55	11/09/2024 10:13:16

Data transfer between tags

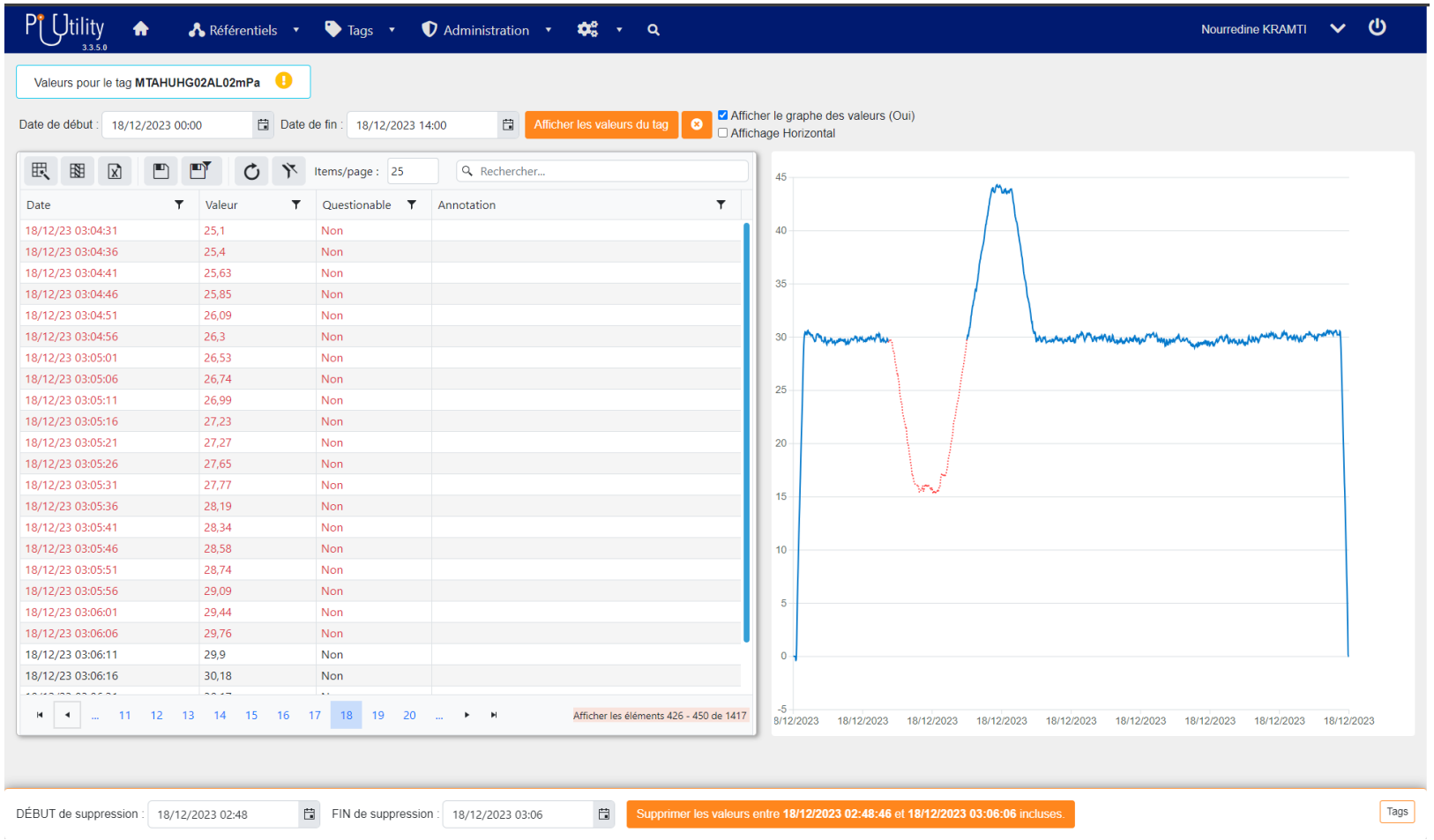
- Data transfer between 2 tags (*)
  - Checks :
    - UOM,
    - Point Source,
    - tags usage,
    - source last value < target first value…



(*) *Modifications applied to all the PI environments*

Invalidate events between two timestamps

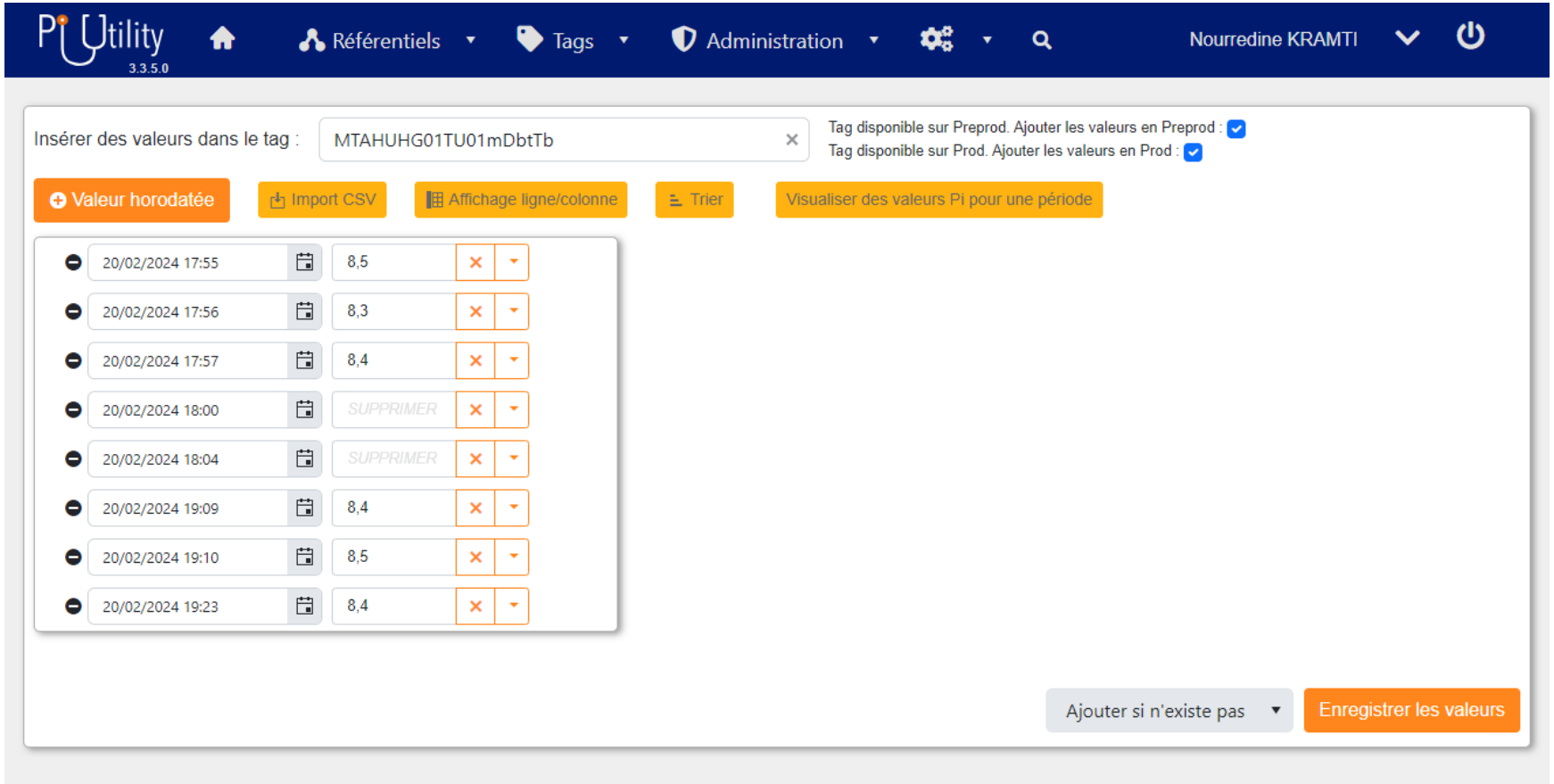
- Invalidate events between two timestamps (*) and set an invalid data Digital state with annotation at the beginning of the period



(*) *Modifications applied to all the PI environments*

Archived events manipulation

- Add, edit or delete PI tag values (*)
- Import data from CSV files (*)



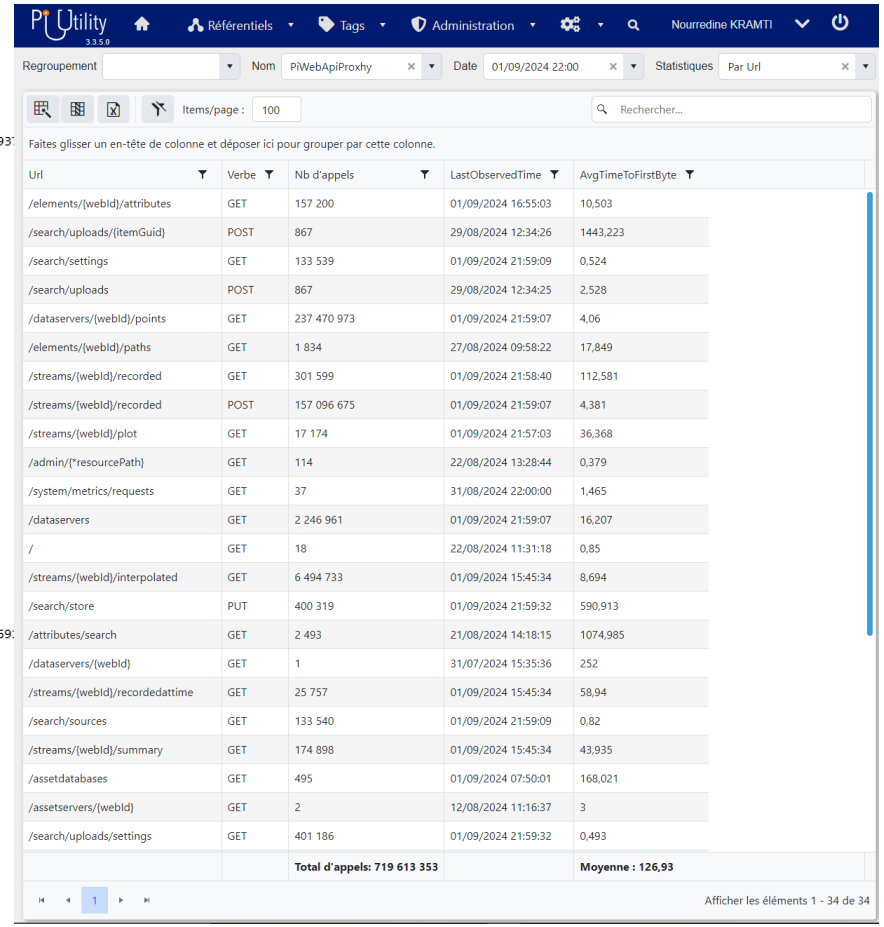
(*) *Modifications applied to all the PI environments*

Additional features

- Visualize PI Web API statistics from all instances
- Data exports to various systems and formats
- Tag lifecycle history (renamed, deleted…)
- Abacus management (used by PI AF & PI Analysis)
- AF Template consistency check between PI databases
- Data transfers between PI environments
- …

Help pages: PI Web API Help > Metrics > Requests


```
{
  "SnapshotTimeStamp": "2024-09-17T12:20:37.4429433Z",
  "Requests": {
    "/search/uploads/settings": {
      "Methods": {
        "GET": {
          "Counts": {
            "0": 6459,
            "10": 1,
            "50": 1,
            "100": 2,
            "250": 1,
            "500": 0,
            "750": 0,
            "1000": 0,
            "5000": 0,
            "30000": 0,
            "60000": 0,
            "120000": 0
          },
          "CountByUser": {
            [redacted] 6464
          },
          "CountByStatusCode": {
            "200": 6464
          },
          "Total": 6464,
          "LastObservedTime": "2024-09-17T12:16:04.93
          "AvgTimeToFirstByte": 0.73
        }
      }
    },
    "/streamsets/{webId}/recorded": {
      "Methods": {
        "GET": {
          "Counts": {
            "0": 811395,
            "10": 51363,
            "50": 8731,
            "100": 2194,
            "250": 462,
            "500": 108,
            "750": 32,
            "1000": 44,
            "5000": 0,
            "30000": 0,
            "60000": 0,
            "120000": 0
          },
          "CountByUser": {
            [redacted]: 282840,
            [redacted] 591486
          },
          "CountByStatusCode": {
            "200": 874329
          },
          "Total": 874329,
          "LastObservedTime": "2024-09-07T02:05:10.69
          "AvgTimeToFirstByte": 4.075
        }
      }
    },
```

Results

Results

- Teams
  - PI System :
    - 2 development engineers focused on PI Utility
    - 2 engineers dedicated to managing AF templates
    - 1 team Leader
  - Hydro monitoring & performance communities :
    - 8 engineers
- Achievements since 2021 :
  - Developed **92 AF templates**, with **~16,000 instances deployed** in production by Michael, resulting in 21,000 tags created
  - Created **29 AF templates to synchronize ~14,000 EDF Hydro assets** with the AF hierarchy
  - Released **67 versions of PI utility**
- Success Factors :
  - Leveraging the openness of the PI System
  - Effective design of PI Utility, enabling :
    - Easy scalability : possibility to deploy thousands of instances of an AF template which is almost impossible manually
    - Reduction of human errors (Tags and instances naming, parameters settings between Ancillary and Production systems)
    - Huge time savings for both the PI System team and the Hydro monitoring community
    - Seamless addition of new features when we need them

Future considerations

What’s next for PI Utility?

- Implementation of new compression settings on existing archived events using swinging door algorithm
- Implementation of data retention policies per tag
- Integration of Predictive Analytics template instances deployment from PI Utility
  - Requires upcoming evolutions on AVEVA Predictive Analytics
- Automation of AF template instances attributes configuration
- …

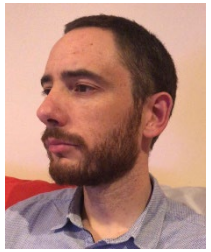
Testimonials from the Hydro monitoring & performance communities

Vincent F.

”PI Utility is an exceptional ergonomic tool that simplifies the creation and management of industrial data with remarkable efficiency and reliability”

Mathieu G.

“PI Utility helps improve monitoring and analysis by quickly and easily developing new user-specified models.
Data creation is instantaneous, reliable, provided with history, named according to a standard and controlled.”



Frédéric G.D.

“The strength lies in offering, through the PI System, technical solutions that improve overall efficiency by focusing development teams on new challenges rather than deployment tasks. PI Utility has enabled the multiplication of use cases and quick gains without overly taxing development resources. I think it is a great success.”

“PI Utility is a simple and effective interface to manage our monitoring data. This is a huge time saver on a daily basis and a guarantee of long-term maintenance of our models.”

Michael B.

“By allowing us to have control over creating new PI tags calculated from existing tags, PI Utility has significantly improved our ability to detect and analyze operating deviations in our hydroelectric facilities. It allows us to develop other operating services such as assistance in carrying out condition-based maintenance.”

Guilhem T.

“PI Utility is an essential tool for us to develop advanced calculation and visualization within PI. Without this tool, our performance monitoring project would not have succeeded. It allows us to easily and flexibly manage PI AF calculation models by non-IT staff without in-depth knowledge of PI.”

Jean H.

POWER GENERATION | FRANCE

EDF Hydro reduces the time needed to deploy AF models instances

Challenge

- Minimize the time spent to deploy AF template instances and enable users to do it
- Automatically generate AF hierarchies from the company's asset repositories
- Extend PI System features

Solution

- Development of PI Utility, a Web Application (.Net 8 C# , Blazor Server and Microsoft SQL Server) interconnected to EDF Hydro asset repositories and the Ancillary and Production PI Systems

Results

- With a team of 6 Hydro monitoring engineers and 5 PI & development, we could deploy 92 AF models and almost 16K AF template instances in production.
  It took 80% less time to deploy them compared if we had to do it manually.
- The development of PI Utility was financed by the time we saved in deploying instances. We had a huge gain in agility, efficiency and quality.

Presenter

- Jérôme BOUDON
- EDF SA, Hydro Division
- PI System Hydro Project Manager
- jerome.boudon@edf.fr

EDF was an actor in that innovation!

Q&A

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