ESSS O&G solutions

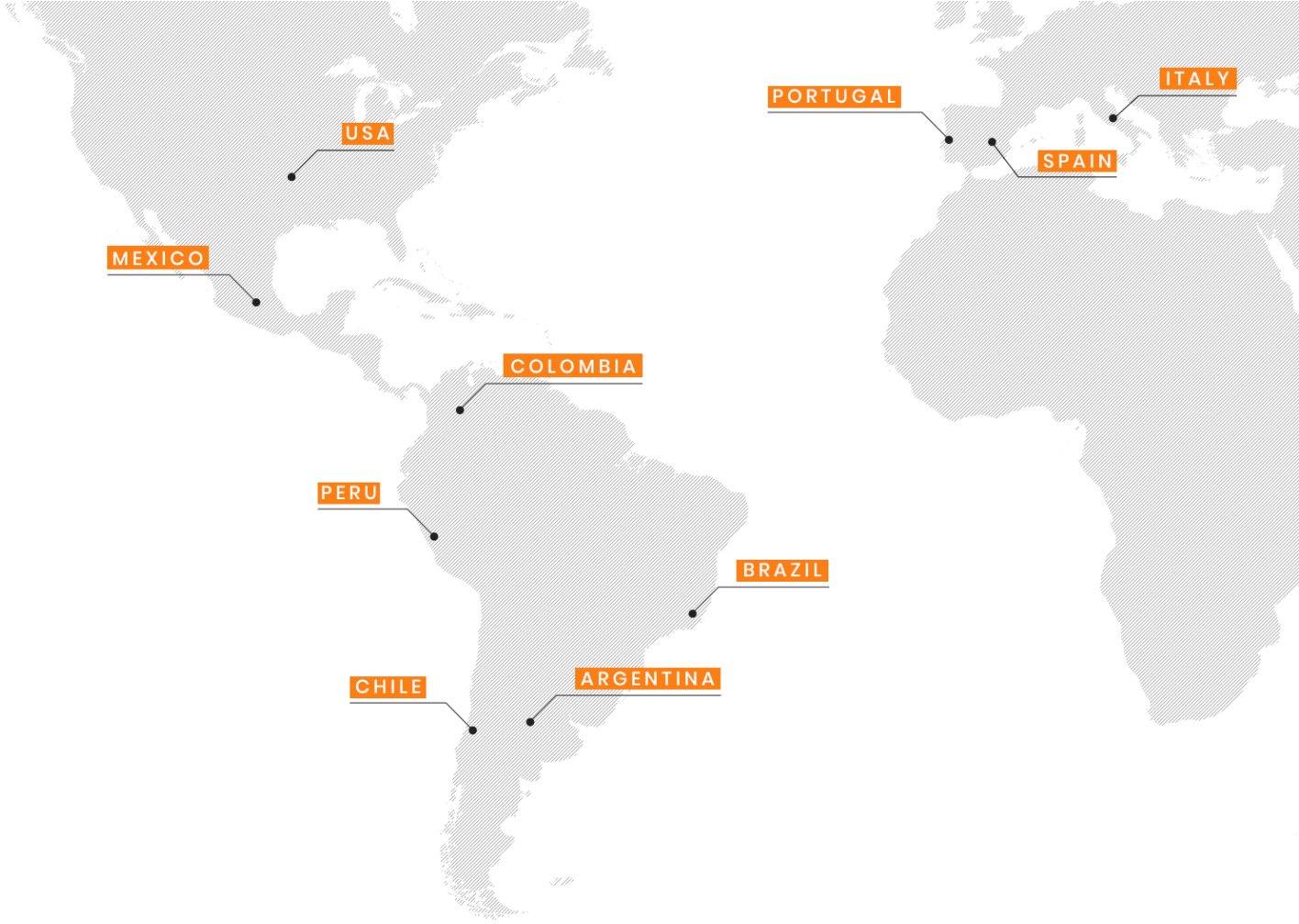
Smarter solutions for your toughest energy challenges

Outline

- About ESSS O&G
- Introduction
- Physics-based modeling
- Hybrid modeling
- Final solution: HYD-ai
- Conclusions

ESSS

Founded in 1995, ESSS is a company internationally recognized for offering **simulation solutions for more than 700 companies** in sectors such as Energy, Aerospace, Mining and Automotive, providing services of high complexity and added value, as an Ansys Elite Channel Partner and the official Ansys software provider for Latin America, Portugal, Spain and Italy, a **world authority in computer simulation**.



Global Presence

Offices in more than 10 countries

ESSS O&G

About us

ESSS O&G is a global provider of fit-for-purpose simulation and services to the E&P companies. Upstream business work with us to get the most reliable insights and diagnostics from their **reservoir, wells and pipelines**, so they can always produce at **optimum levels.**

Technology surrounded by people

Nearly **80 multi-disciplinary experts** with cross industry experiences and specific focus on energy, M.S. and Ph.D.

- **Petroleum Engineering**
- **Mechanical Engineering**
- **Geology**
- **Chemical Engineering**
- **Physics & Mathematics**
- **Computer Sciences & Engineering**

Solutions for decision-making

- Digitalization and Modeling for the O&G/Energy industry
- Fit for service scientific engineering applications
- Proprietary technology

Reservoir Engineering

Production & Transport

Drilling & Completions

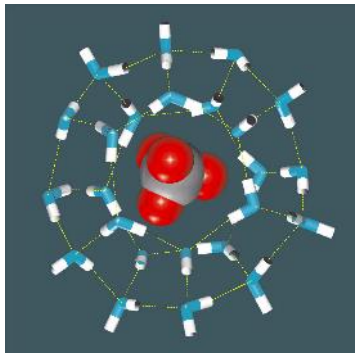
Energy Transition

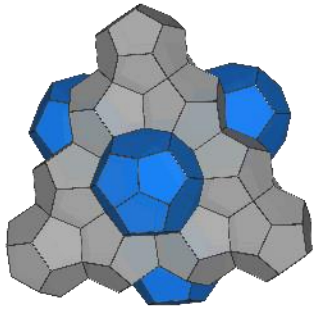
Outline

- About ESSS O&G
- Introduction
- Physics-based modeling
- Hybrid modeling
- Final solution: HYD-ai
- Conclusions

What are gas hydrates?

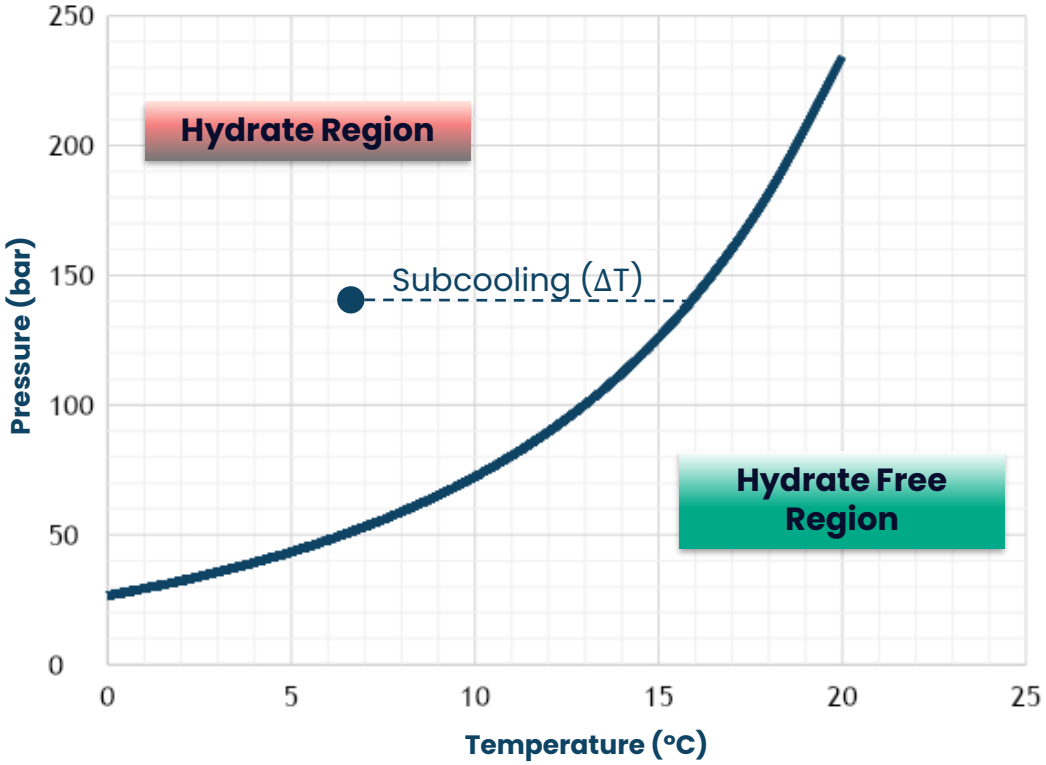
- Crystalline solid formed of water and gas
- Water molecules trap gas molecules in cavities
- Ice-like visual aspect, containing huge amounts of methane
- Natural gas hydrates become solid in temperatures above 0°C





Source: Petrobras

How does a hydrate blockage occurs?



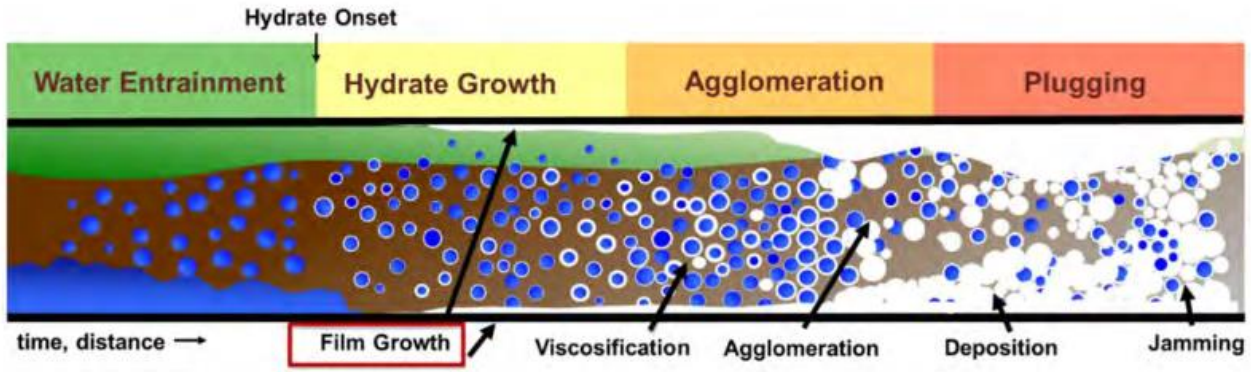


Figure 1—Conceptual picture of hydrate plugging mechanism in oil-dominated systems. Adapted from Turner and Srivastava (D. J. Turner 2005; Srivastava 2018; Qin et al. 2019).

OTC-30545-MS

Predicting Hydrate Plugging Risk in Oil Dominated Systems using a Transient Hydrate Film Growth Prediction Tool

Hao Qin, Angi Qu, Yan Wang, Luis Zerpa, and Carolyn Koh, Colorado School of Mines; Scot Bodnar and Sean Daly, Multi-Chem Halliburton; Thierry Palermo and Khalid Mateen, Total

ESSS O&G

What are the most relevant characteristics to quantify the hydrate formation risk?

- High BSW
- Free water
- Blockage history
- Hydrate rheology

Situations in which hydrate formation and blockage occurred.

Situations in which hydrate blockage as expected, but it didn't occur.

- Salinity
- GOR/GLR
- Subcooling
- SDS
- Bathymetry
- Etc.

TOO MANY VARIABLES

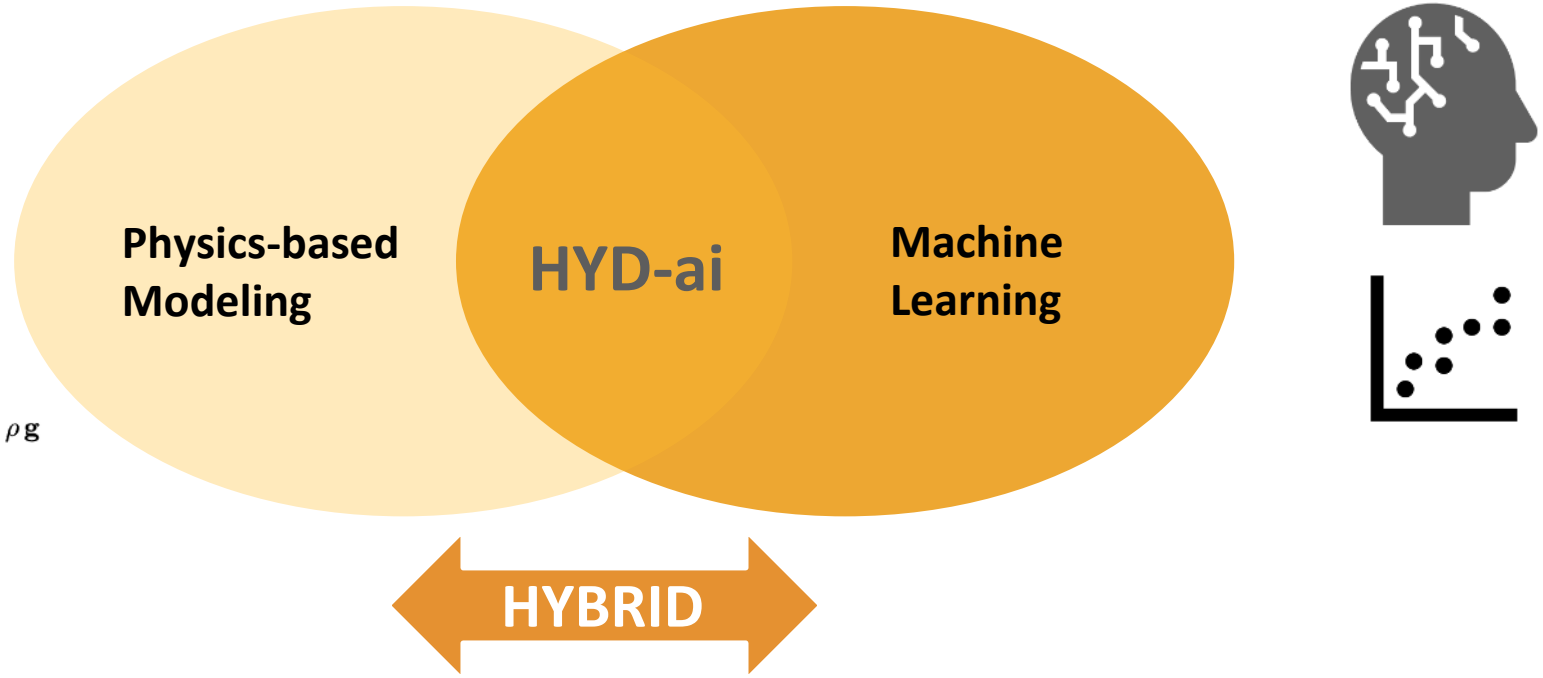
ESSS O&G

HYD-ai

Hybrid AI for real time hydrate risk monitoring

$$\frac{\partial \rho}{\partial t} + \nabla \cdot (\rho \mathbf{u}) = 0$$

$$\frac{\partial}{\partial t}(\rho \mathbf{u}) + \nabla \cdot (\rho \mathbf{u} \otimes \mathbf{u}) = -\nabla p + \nabla \cdot \boldsymbol{\tau} + \rho \mathbf{g}$$



ADVANTAGES	▪ Predictive, physics based ▪ Low amount of data	▪ Speed ▪ Easy deployment and scalability
CHALLENGES	▪ Computational / numerical challenges ▪ Model complexity ▪ Data quality for model calibration	▪ Data volume/variety requirements ▪ Data quality for model training ▪ Statistical unsteadiness (transient operations)

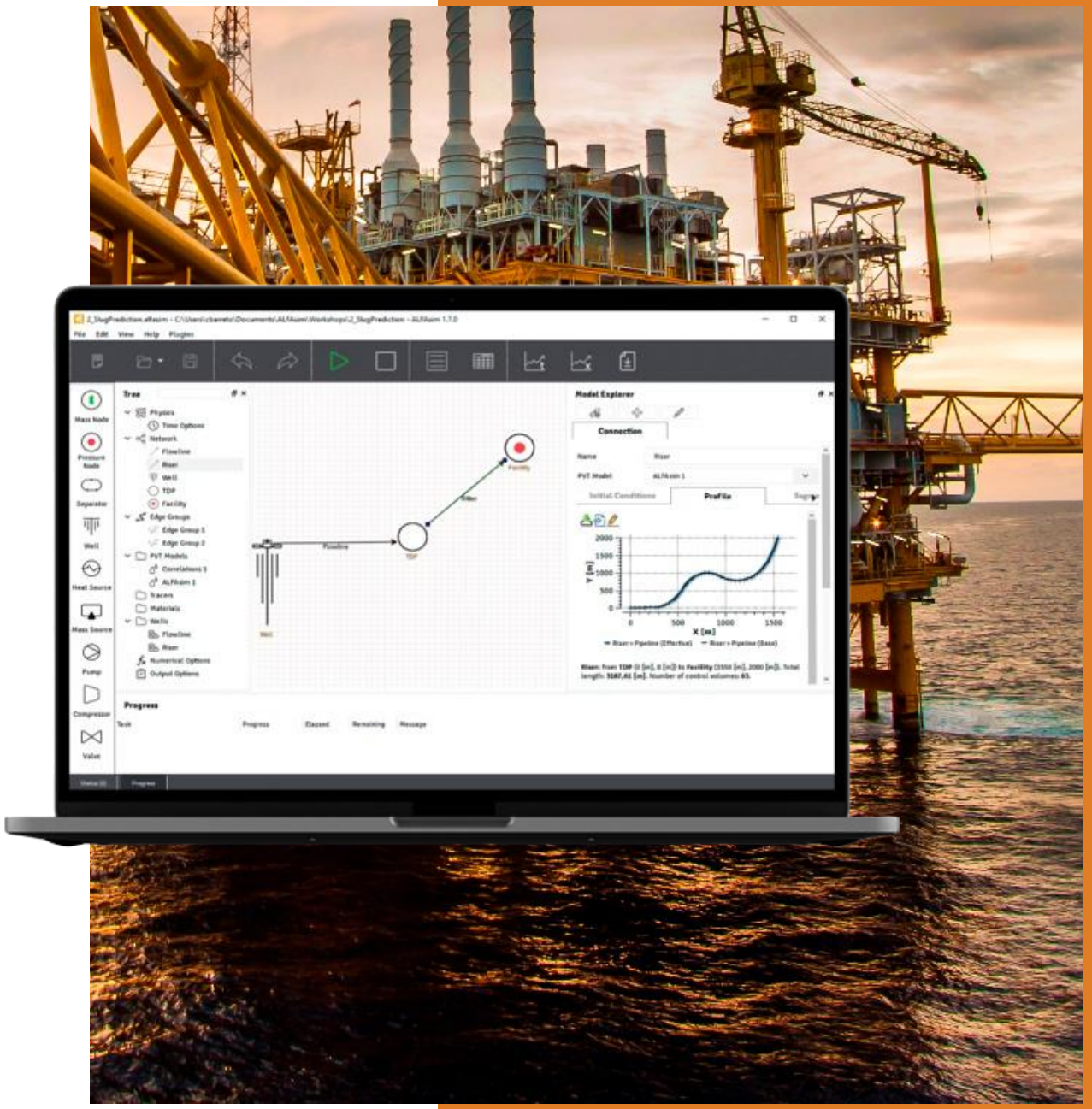
ESSS O&G

Outline

- About ESSS O&G
- Introduction
- Physics-based modeling
- Hybrid modeling
- Final solution: HYD-ai
- Conclusions

ALFAsim

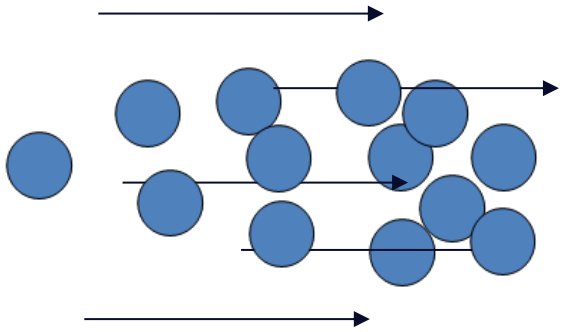
- **Transient** and **Steady-state** modeling of wells and pipelines
- Robust fluid modeling: **PVT tables, black-oil correlations and compositional tracking**
- Complete representation of equipments: chokes, pumps, gas-lift valves, reservoirs, mass/heat sources, etc..
- **Robust customization framework** that allows users to input proprietary models and integration with complex workflows
- Simulation of **flow assurance challenges** such as wax deposition, **hydrates**, scaling, corrosion, erosion and inorganic scaling

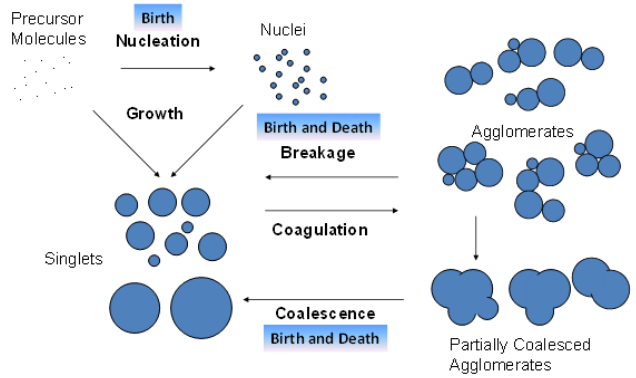


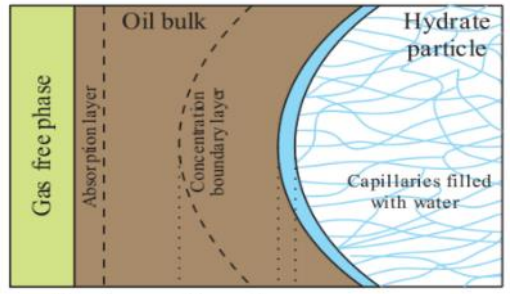
ALFAsim plugins

Hydrates plugin

SFR	x	PBM	x	PBM + Bassani et al.
Combined nucleation + growth rates	———	*Separated nucleation and growth phenomenon*	———	*Hydrate particles Cristalization / Porosity evolution*
Constant size of hydrate particles (user input)	———	*Population Balance equation to define particle sizes*	———	*Population Balance equation to define particle sizes*
Agglomeration and break not considered	———	*Agglomeration e break are considered*	———	*Agglomeration e capillary bridge disruption are considered*







ESSS O&G

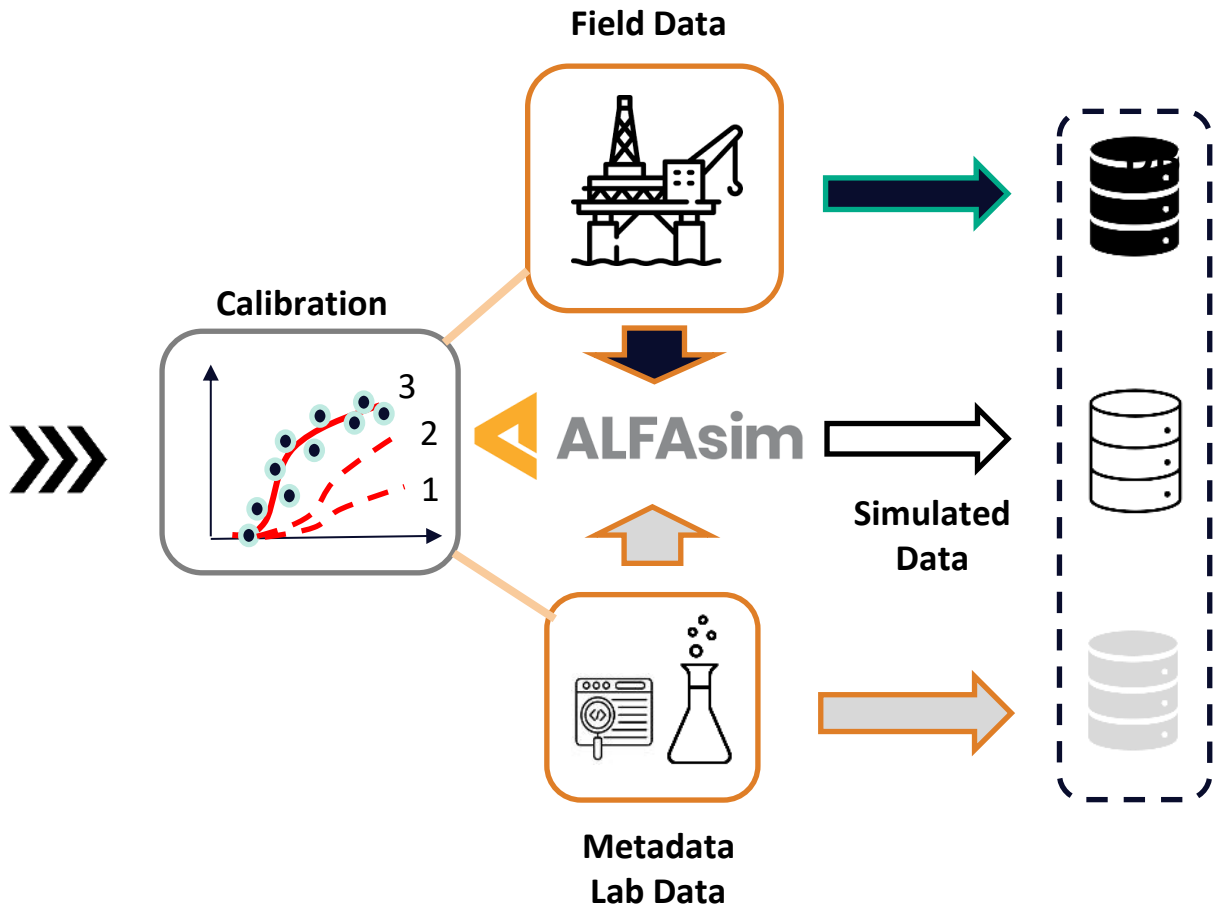
Outline

- About ESSS O&G
- Introduction
- Physics-based modeling
- Hybrid modeling
- Final solution: HYD-ai
- Conclusions

Hybrid Modeling

Stage 1: Database (DB) Generation

- Sensors data (PDG, TPT, etc)
- Simulation models
- Metadata (BSW, salinity, gas chromatography, PI, well tests, hydrates occurrence)
- PVT analysis
- Rheology reports



Offline

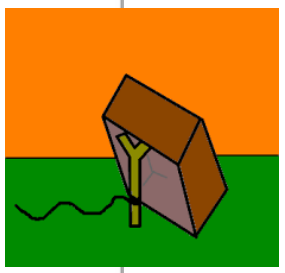
Current 3W dataset: public version

1964 instances

- 1025 real instances
- 939 simulated instances
- 84 positive instances
- 1880 negative instances

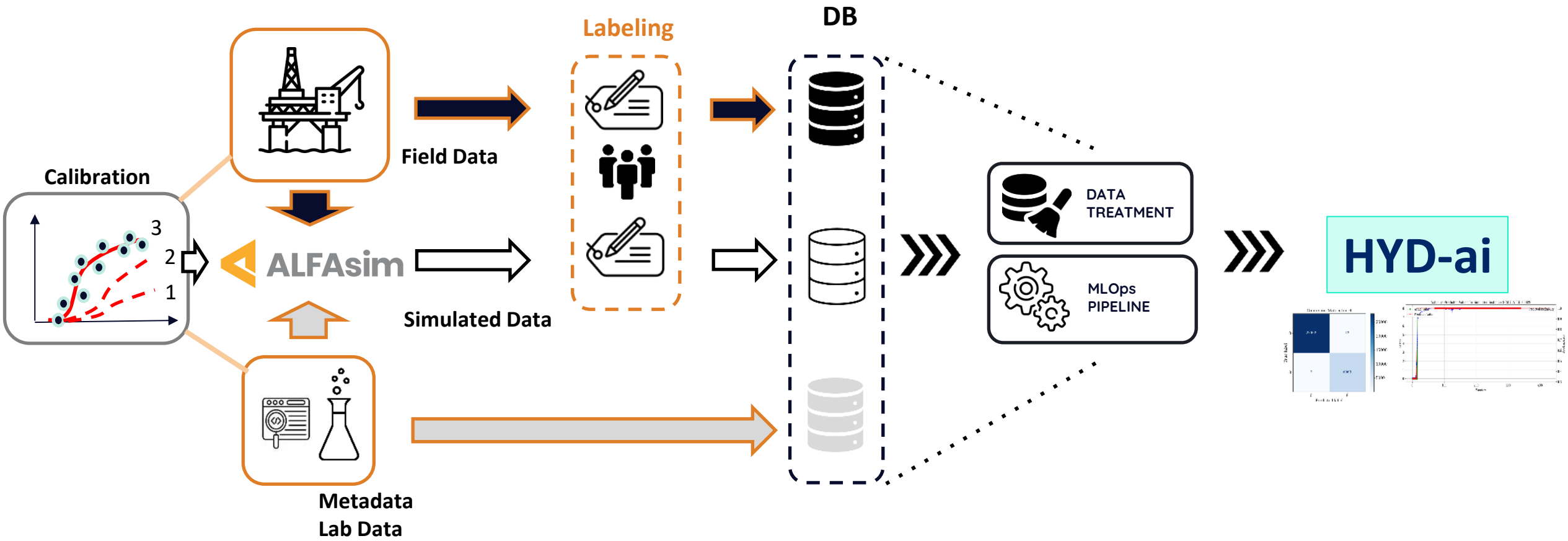
Table 2
Quantities of instances that compose the 3W dataset.

TYPE OF EVENT	REAL	SIMULATED
	INSTANCES	
0 – NORMAL	597	–
1 – ABRUPT INCREASE OF BSW	5	114
2 – SPURIOUS CLOSURE OF DHSV	22	16
3 – SEVERE SLUGGING	32	74
4 – FLOW INSTABILITY	344	–
5 – RAPID PRODUCTIVITY LOSS	12	439
6 – QUICK RESTRICTION IN PCK	6	215
7 – SCALING IN PCK	4	–
8 – HYDRATE IN PRODUCTION LINE	3	81
TOTAL	1025	939



Hybrid Modeling

Stage 2: Classifier Development



Labeling hydrate real cases

Operating well

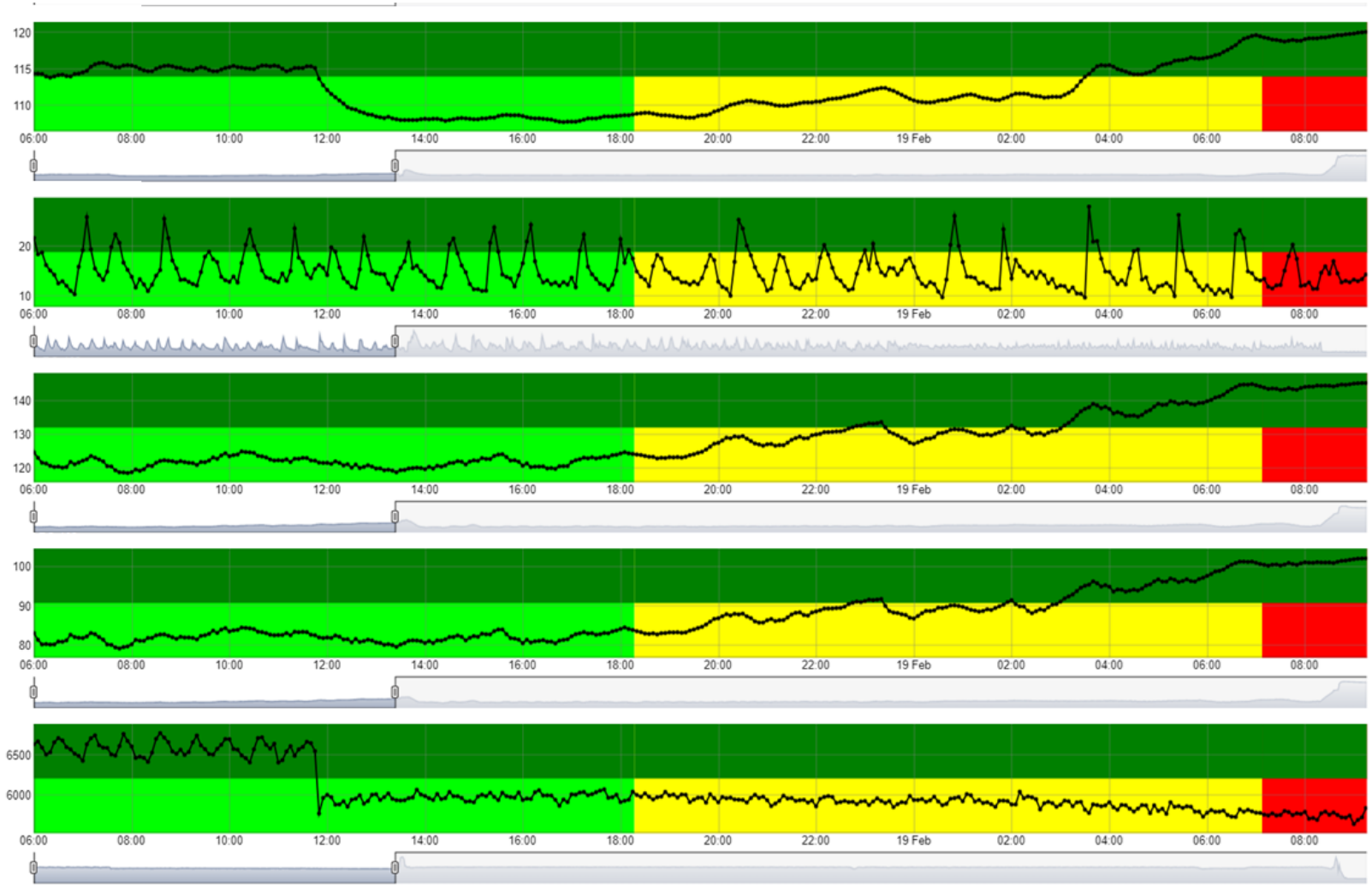
P-JUS-CKGL

P-MON-CKP

P-PDG

P-TPT

QGL



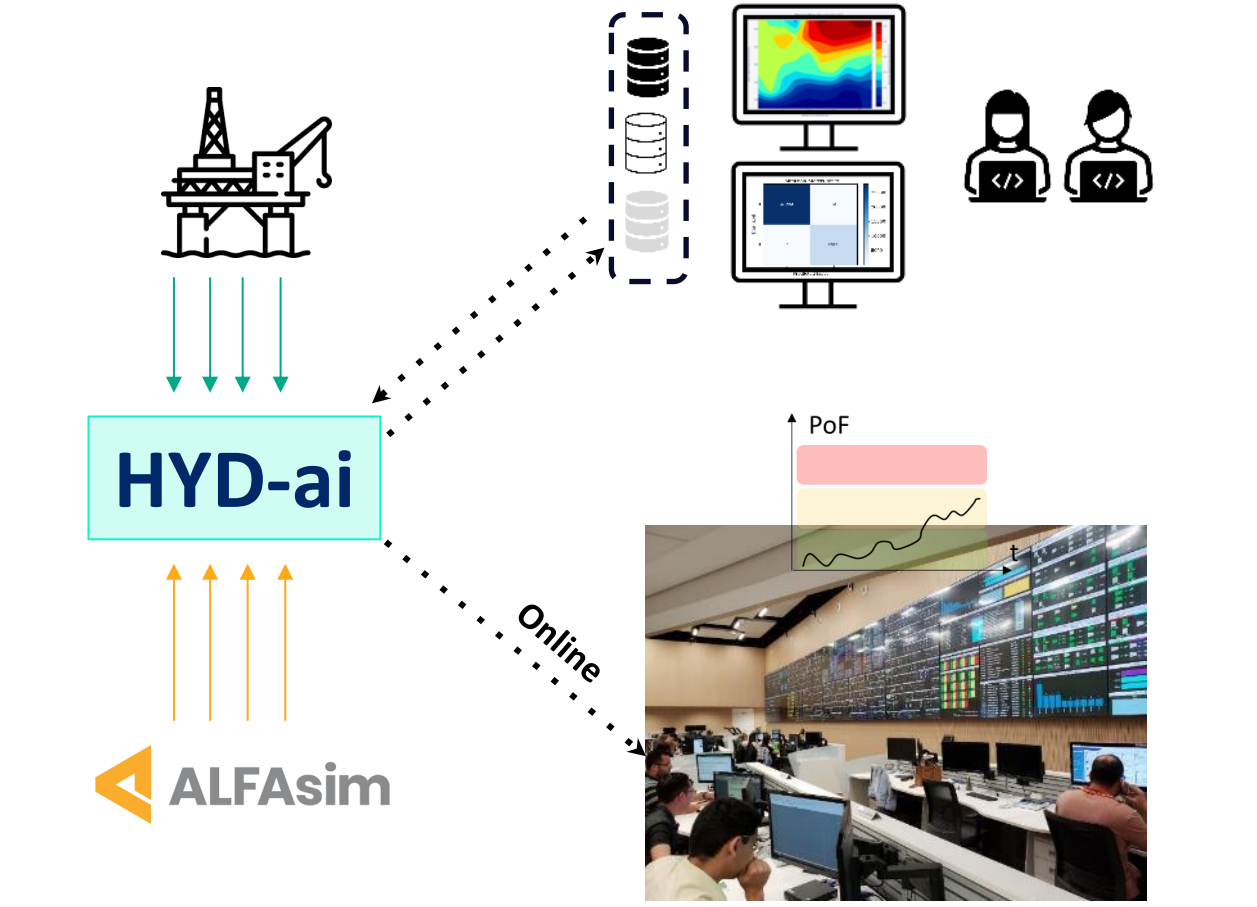
Labeling hydrate real cases

Closed well with multiple stages

- Well shut-in
- 3 start-up attempts
- Well shut-in
- Production Line depressurization until Psep
- Production Line depressurization until Patm
- Bullheading
- Production Line blockage

Hybrid Modeling

Stage 3: Inference (prediction and risk monitoring)



Online

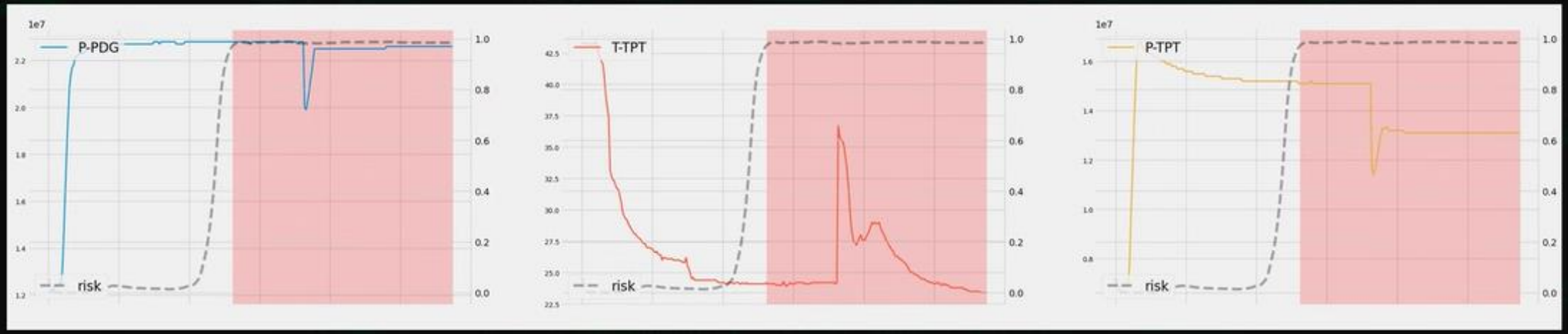
Outline

- About ESSS O&G
- Introduction
- Physics-based modeling
- Hybrid modeling
- **Final solution: HYD-ai**
- Conclusions

Final Solution: HYD-ai

HYD-ai

- Different models were trained for different operation domains, using a diverse and robust dataset composed by real and simulated instances based on historical cases of hydrate blockage in production lines



Predictions from the latest model trained using real instances in test set during a SI period.

HYD-ai Frontend

- Visualization of real and simulated instances (dataset versioning)
- Instances labeling
- Well risk maps
- Classifier models performance evaluation (training)
- Classifier models performance evaluation (inferring)

HYD-ai - Hyd-AI

INSTANCES

Instances
Metrics
AI Models
What If

Details | Select instances

ID_1340_ABL-84_20180612060124_1285N

Variables

P-TPT

T-PDG

T-MON-CKP

T-TPT

ABL-84_20181016054734

Variables

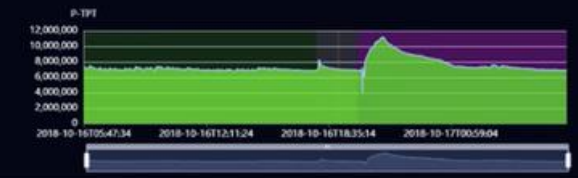
ESTADO-M1

Search ..

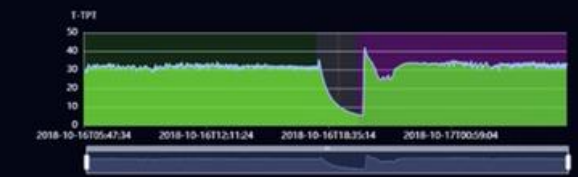
QGL
T-JUS-CKP
T-MON-CKP
T-PDG
✓ T-TPT
class
state

P-MON-CKP

P-TPT



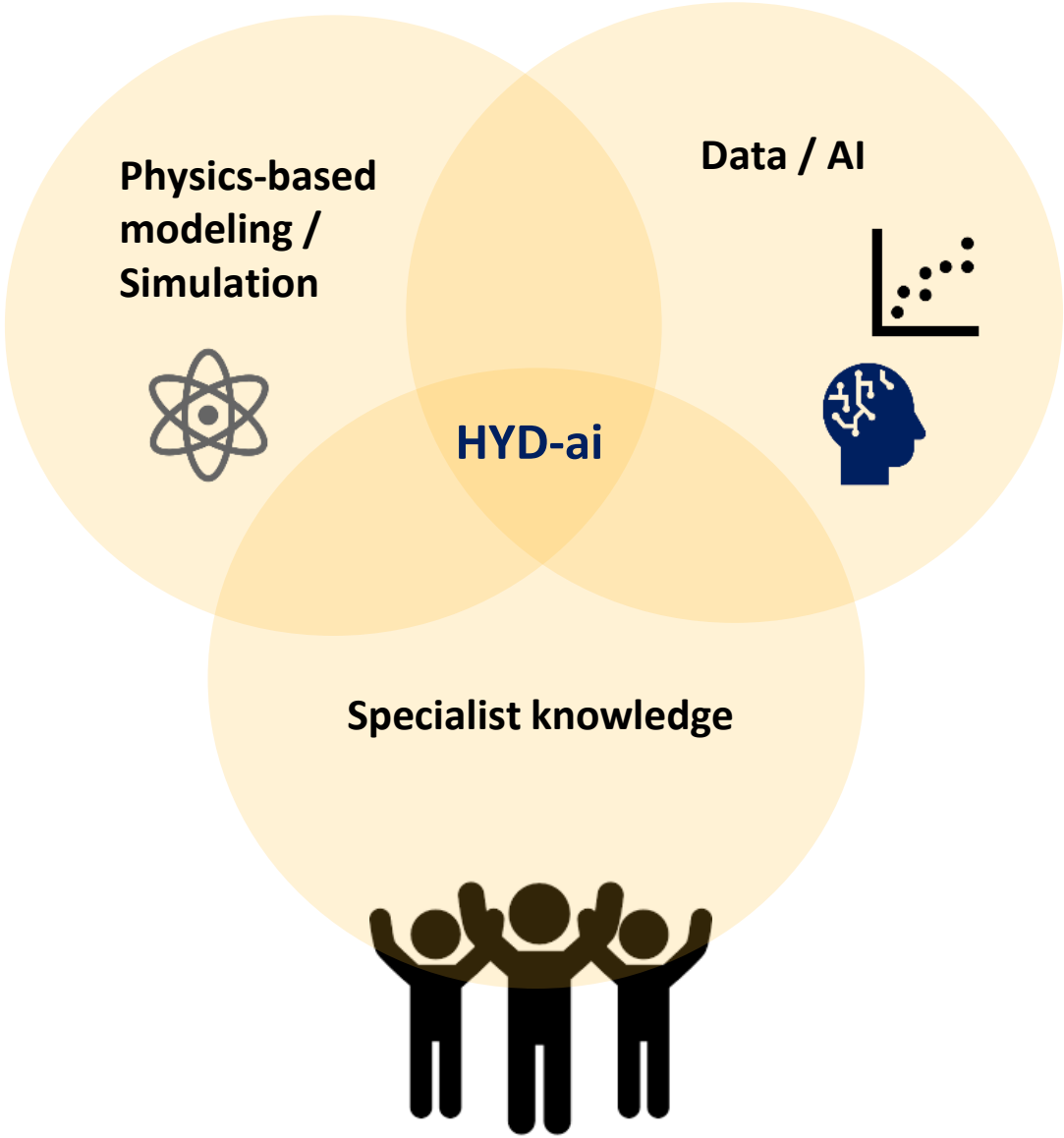
T-TPT



Outline

- About ESSS O&G
- Introduction
- Physics-based modeling
- Hybrid modeling
- Final solution: HYD-ai
- Conclusions

Conclusions



Aknowledgements

PETROBRAS

ISDB research and innovation

ESSS O&G

hai HYBRID ARTIFICIAL INTELLIGENCE

HYD-ai CONSORTIUM

ESSS O&G

GET IN TOUCH WITH OUR OIL AND GAS EXPERTS

Let’s talk about how we can help your company go further

CONTACT US