Digitalization, virtual measurements and digital twins in gas processing

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Outline

- Gas Technology (TEP4185)
- The gas value chain
- Digital tools in teaching and for problem solving
- NeqSim – an open source process simulation tool developed at NTNU
- From a live process simulator to a process digital twin
- Future gas value chains

Gas Technology (TEP4185)

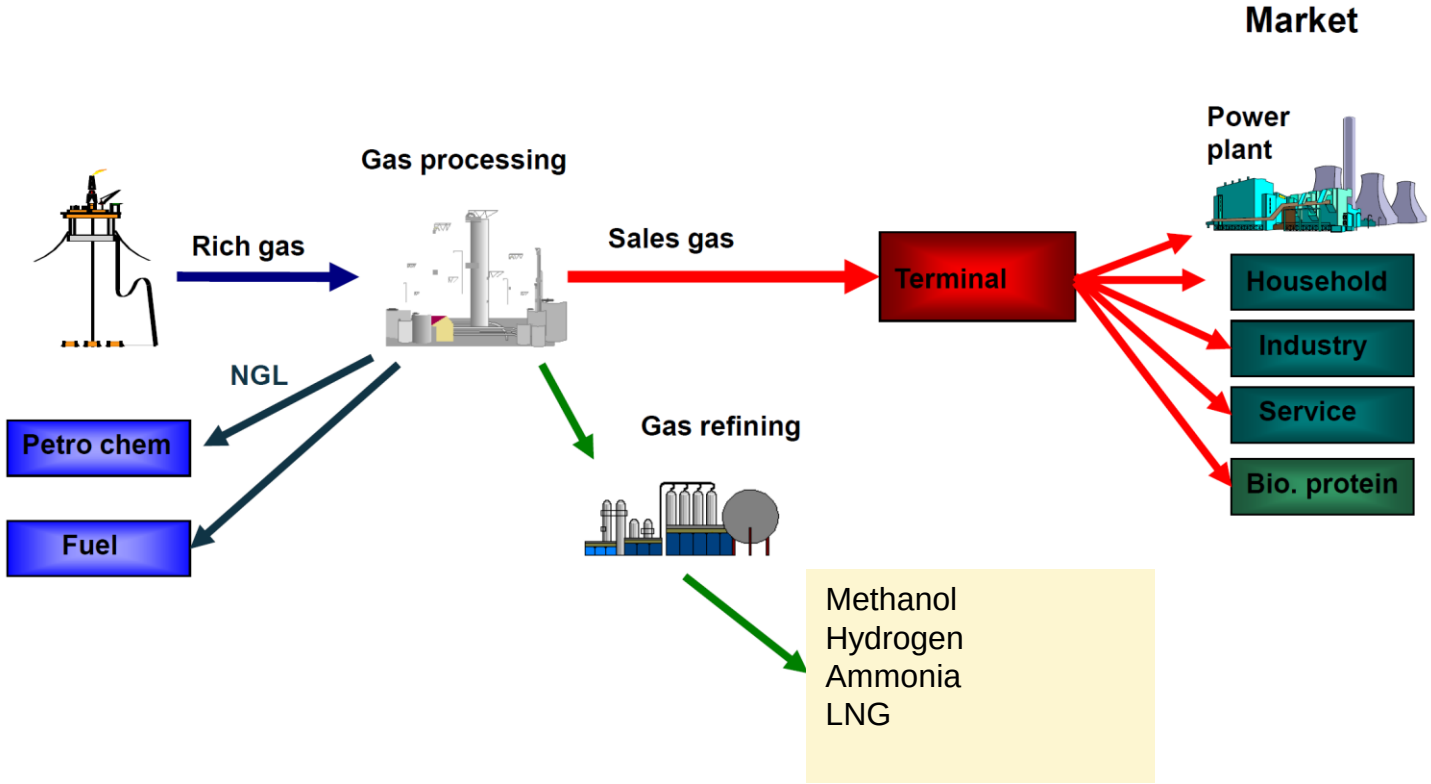
- Thermodynamics
- Process simulation
- Gas value chain
- Gas processing
- Power generation
- Hydrogen production
- CO_2 capture
- Cryogenic gas processing

TEP 4185 Gas Technology — Updated 07.11.2022

Date	Time	Type	Topic	Lecturer	Place
23.aug	10:15-12:00	Exercise	No exercise		R91
24.aug	13:15-16:00	Lecture	**Information/outline/motivation** Course outline and practical information	LN/ES/GM	EL1
26.aug	08:15-10:00	Digital exercise	No exercise		Blackboard
30.aug	10:15-12:00	Exercise	Python exercise P1	Vit.ass.	R91
31.aug	13:15-16:00	Lecture	**Thermodynamics for gas technology** Engineering thermodynamics important for gas technology	ES/LN	EL1
02.sep	08:15-10:00	Digital exercise	Python exercise P1	Vit.ass.	Blackboard
06.sep	10:15-12:00	Exercise	Computer Exercise CE1 - Getting started with HYSYS	Video, stud.ass.	R91
07.sep	13:15-16:00	Lecture	**Process simulation primer** Process modeling and simulation	LN/ES	EL1
09.sep	08:15-10:00	Digital exercise	Intro to exercise CE2 - Gas processing	ES	Blackboard
13.sep	10:15-12:00	Exercise	CE2 - Gas processing	Stud.ass.	R91
14.sep	13:15-16:00	Lecture	**Gas Processing** Gas value chain	ES	EL1
16.sep	08:15-10:00	Digital exercise	CE2 - Gas processing	Stud.ass.	Blackboard
20.sep	10:15-12:00	Exercise	CE2 - Gas processing	Stud.ass.	R91
21.sep	13:15-16:00	Lecture	**Gas Processing** Offshore processes	ES	EL1
23.sep	08:15-10:00	Digital exercise	CE2 - Gas processing	Stud.ass.	Blackboard
27.sep	10:15-12:00	Exercise	CE2 - Gas processing	Stud.ass.	R91
28.sep	13:15-16:00	Lecture	**Gas Processing** Onshore processes	ES	EL1
30.sep	08:15-10:00	Digital exercise	CE2 - Gas processing	Stud.ass.	Blackboard
04.okt	10:15-12:00	Exercise	CE2 - Gas processing	Stud.ass.	R91
05.okt	13:15-16:00	Lecture	**Hydrogen production** Overview and focus on reforming of natural gas	GM	EL1
07.okt	08:15-11:00	Exercise	CE2 - Gas processing	Stud.ass.	C201
11.okt	Group-wise	Presentation	**CE2 - Presentation Gas processing**	ES/Vit.ass.	C201
12.okt	13:15-16:00	Lecture	**CO_2 capture** Overview and focus on separation of CO2 with chemical absorption	GM	EL1
14.okt	08:15-10:00	Digital exercise	Intro to exercise CE3 - Power generation	Stud.ass.	Blackboard
18.okt	10:15-12:00	Exercise	Excercises P2, P3, CE3 - Power generation	Stud.ass.	R91
19.okt	13:15-16:00	Lecture	**Power generation** Turbomachinery fundamentals	LN	EL1
21.okt	08:15-10:00	Digital exercise	Excercises P2, P3, CE3 - Power generation	Stud.ass.	Blackboard
25.okt	10:15-12:00	Exercise	Excercises P2, P3, CE3 - Power generation	Stud.ass.	R91
26.okt	13:15-16:00	Lecture	**Power generation** Gas turbine off-design operation. Gas turbine performance modeling.	LN	EL1
28.okt	08:15-10:00	Digital exercise	Excercises P2, P3, CE3 - Power generation	Stud.ass.	Blackboard
01.nov	10:15-12:00	Exercise	Excercises P2, P3, CE3 - Power generation	Stud.ass.	R91
02.nov	13:15-16:00	Lecture	**Power generation** Combined cycles	LN	EL1
04.nov	08:15-10:00	Digital exercise	Excercises P2, P3, CE3 - Power generation	Stud.ass.	Blackboard
08.nov	10:15-12:00	Exercise	Excercises P2, P3, CE3 - Power generation	Stud.ass.	R91
09.nov	08:15-11:00	Exercise	CE3 - Power generation	Stud.ass.	C201
09.nov	13:15-16:00	Lecture	**Cryogenic gas processing**	PN	EL1
11.nov	08:15-10:00	Digital exercise	Excercises P2, P3, CE3 - Power generation	Stud.ass.	Blackboard
15.nov	Group-wise	Presentation	**CE3 - Presentation Power generation**	LN/Vit.ass.	C201
16.nov	13:15-16:00	Lecture	**Spare lecture**		EL1
18.nov	08:15-10:00	Digital exercise	No exercise		Blackboard
22.nov	10:15-12:00	Exercise	No exercise		R91
23.nov	13:15-16:00	Lecture	**Summary and Q&A for exam**	ES/LN	EL1
25.nov	08:15-10:00	Digital exercise	No exercise		Blackboard

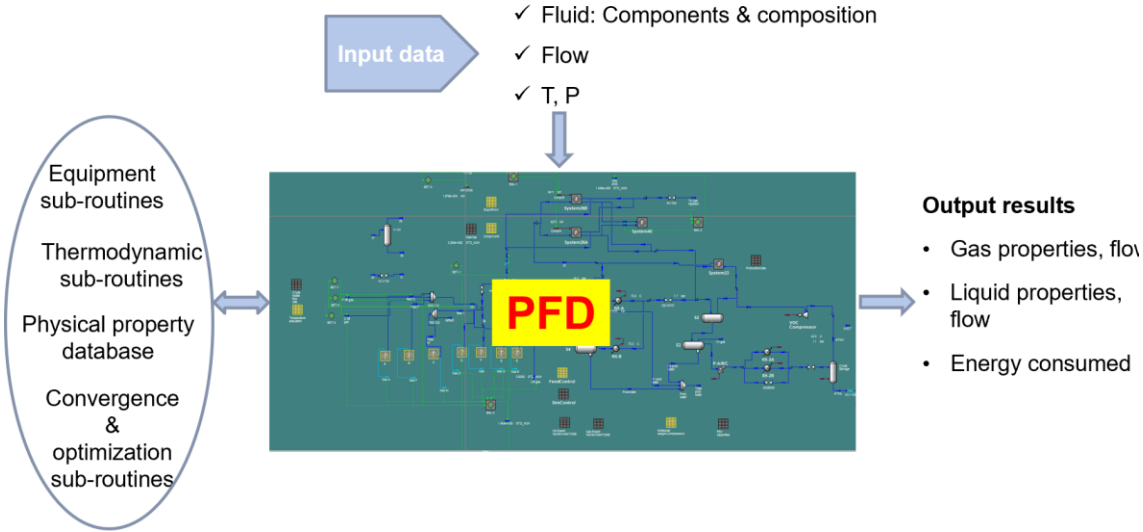
ES = Even Solbraa
LN = Lars Nord
PN = Petter Nekså
GM = Gaurav Mirlekar

The Gas Value Chain



Use of digital tools in teaching and for problem solving

- Lectures are recorded via Panopto and available via course homepage in Blackboard (23.11.2022)
- Exercise introduction are done online via Blackboard Collaborate
- Students learn to establish and run process simulations in HYSYS
- Python exercises (P1/CE2)



NeqSim

NeqSim is a library for estimation of behaviour and properties of fluids. NeqSim is available for free use and distributed as open source under the Apache-2.0 licence.

News:

15/04/2022: Version 2.3.3 released

Contact project via email

View the Project on GitHub
equinor/neqsimhome

NeqSim - an open source process simulation software

NeqSim is a library for calculation of fluid behavior, phase equilibrium and process simulation. NeqSim can be used as a stand-alone tool via Excel or a web interface. It is integrated in computer programs via available interfaces in Java, Python, .NET, Matlab or in process simulators via the Cape Open interface. The basis for NeqSim is fundamental mathematical models related to unit operations, phase behaviour and physical properties of fluids. NeqSim is used for fluids such as oil and gas, carbon dioxide, refrigerants, hydrogen, ammonia, water and chemicals.

The original NeqSim web page is hosted at NTNU

NeqSim project in GitHub

The NeqSim library is written in the Java programming language. The source code and libraries are hosted in GitHub

- NeqSim Java

NeqSim toolboxes in GitHub

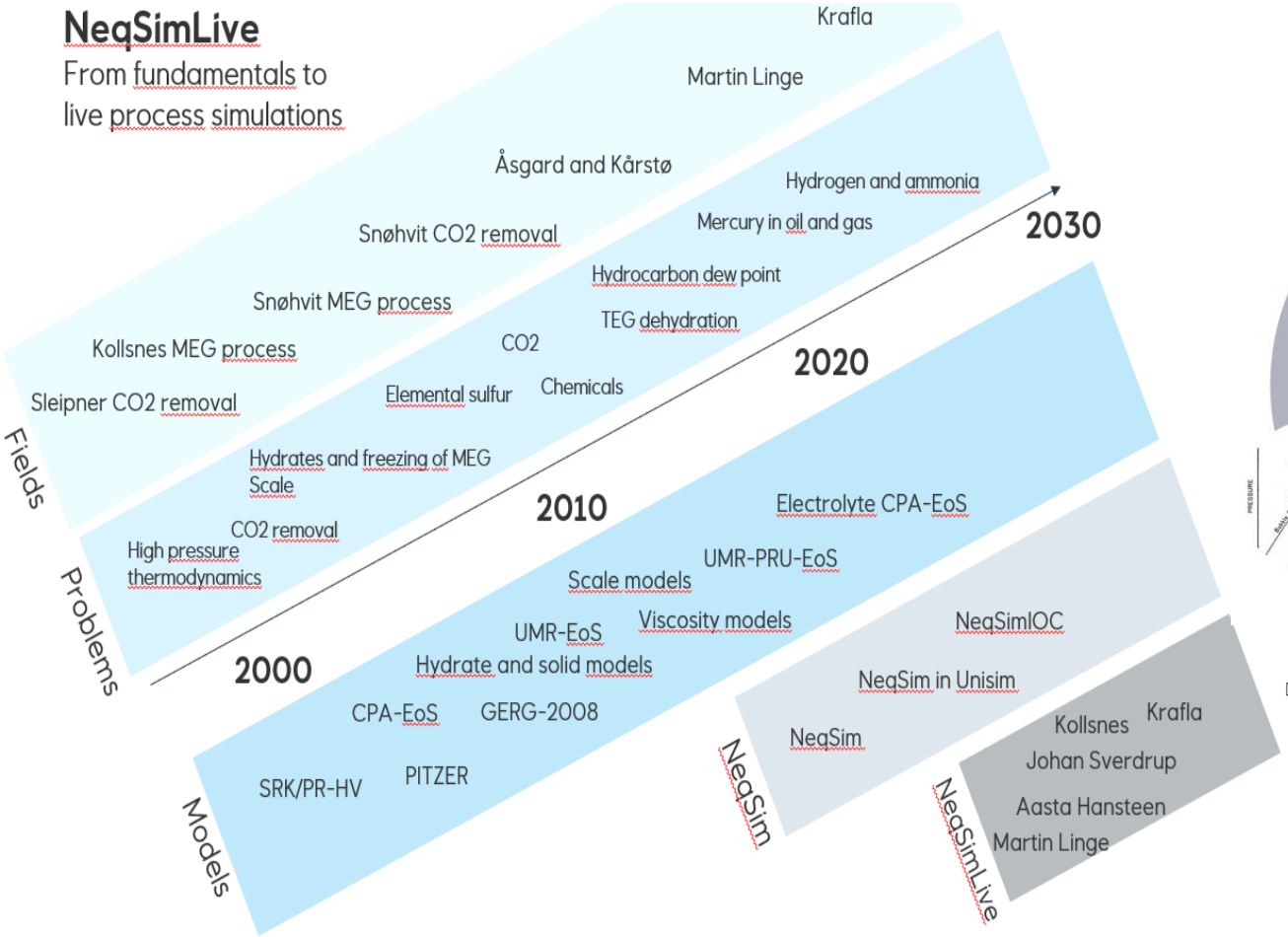
NeqSim toolboxes are avalable via GitHub for alternative programming languages.

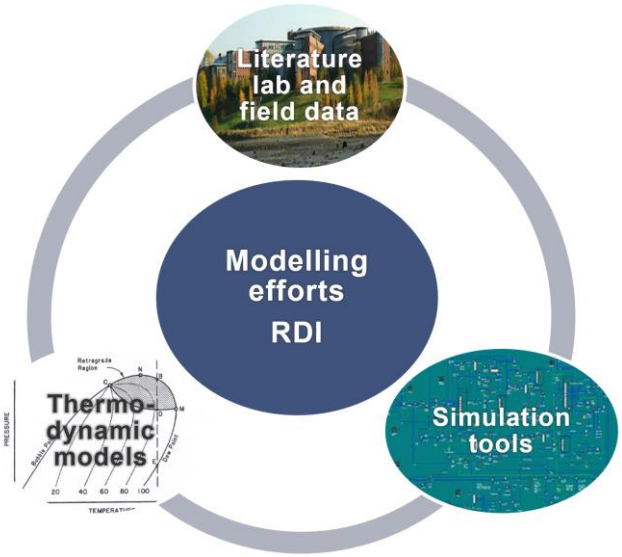
- NeqSim Matlab
- NeqSim Python
- NeqSim .NET
- NeqSim Excel/Cape-Open

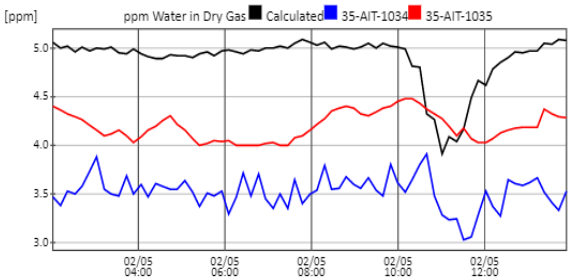
Code development and maintenance in GitHub

NeqSimLive

From fundamentals to live process simulations

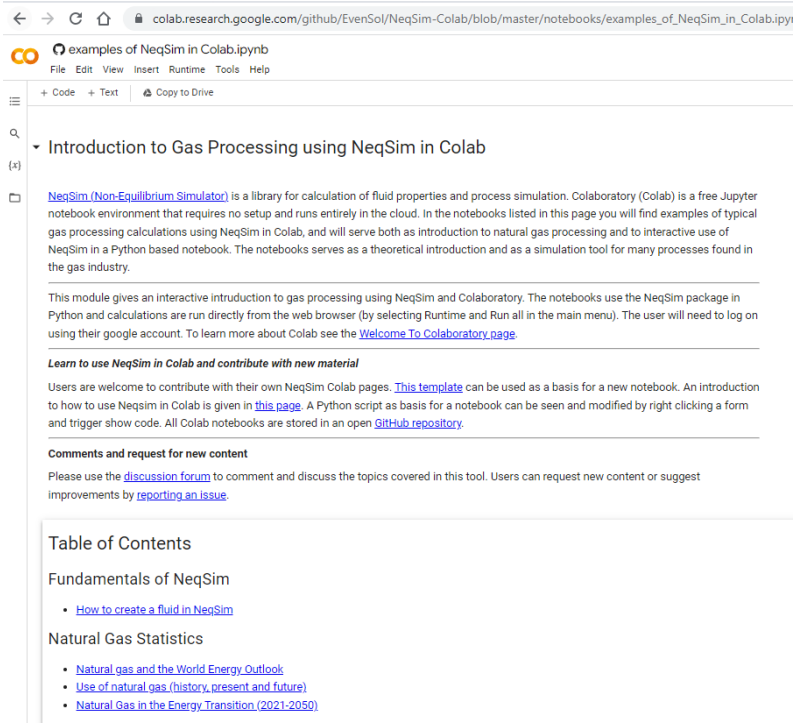






Use of NeqSim as a process simulator in Python

Introduction to gas processing in Python

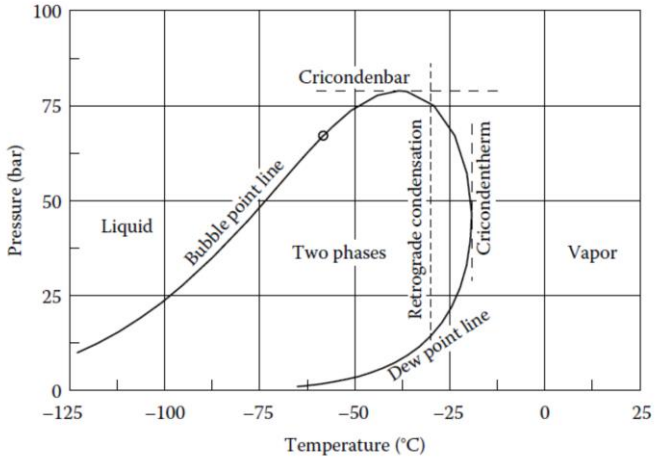


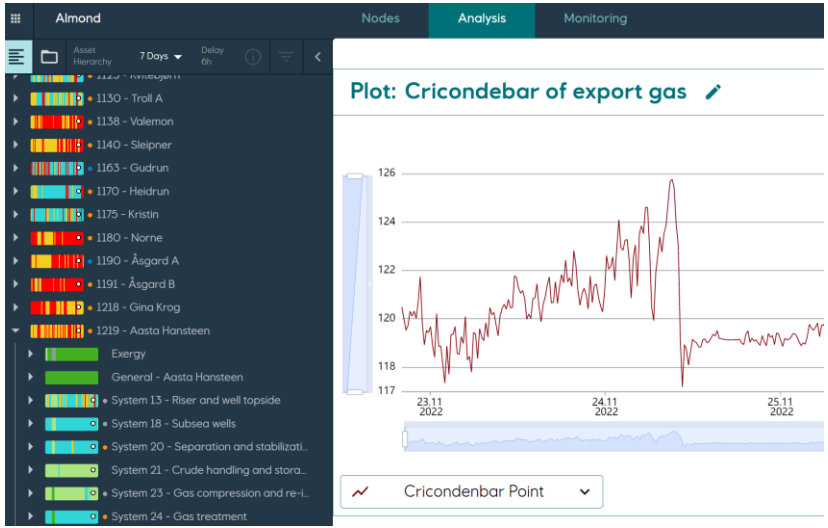

```
chokeValve = valve(wellFlowLine.getOutStream())
chokeValve.setOutletPressure(inputdata['firstStagePressure'], 'bara')

feedToOffshoreProcess = stream(chokeValve.getOutStream())
feedToOffshoreProcess.setName("feed to offshore")

firstStageSeparator = separator3phase(feedToOffshoreProcess)
firstStageSeparator.setName("1st stage separator")

oilHeaterFromFirstStage = heater(firstStageSeparator.getOilOutStream())
oilHeaterFromFirstStage.setName("oil heater second stage")
oilHeaterFromFirstStage.setOutTemperature(inputdata['temperatureOilHeater'],'C')

oilThrotValve = valve(oilHeaterFromFirstStage.getOutStream())
oilThrotValve.setName("valve oil from first stage")
oilThrotValve.setOutletPressure(inputdata['secondStagePressure'])

secondStageSeparator = separator3phase(oilThrotValve.getOutStream())
secondStageSeparator.setName("2nd stage separator")

oilThrotValve2 = valve(secondStageSeparator.getOilOutStream())
oilThrotValve2.setName("valve oil from second stage")
```

Figure: Example of a NeqSim Process model in Python

Development of a Live Process Simulator

1. Validation of process simulation models
2. Tune process model to historic field data
3. Implement machine learning to improve the digital twin (hybrid models)
4. Company integrates model (API based) into its live monitoring tools





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Applications of a live process simulator

- Basis for the process digital twin
- Virtual measurements
- Performance monitoring
- Live energy optimization
- Process maintenance planning
- Data validation and sensor reconciliation

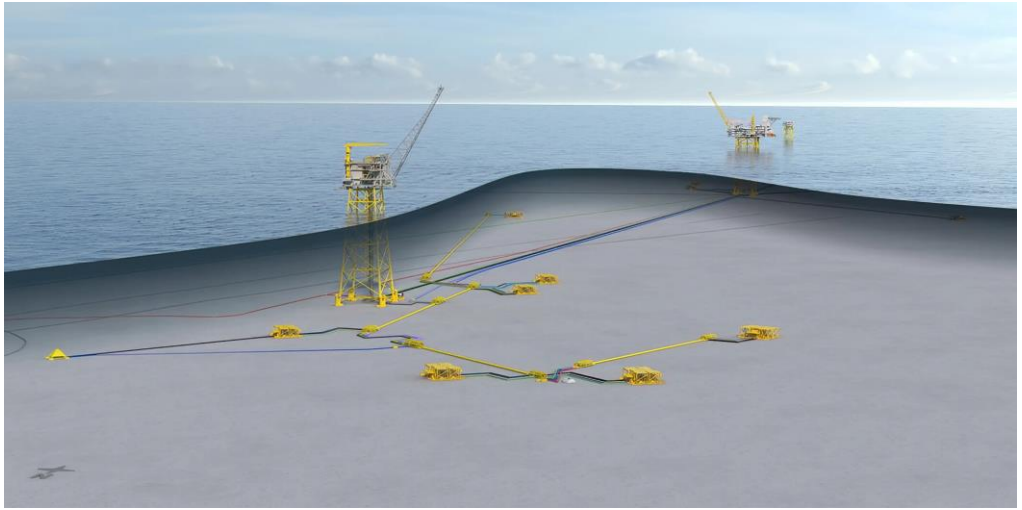
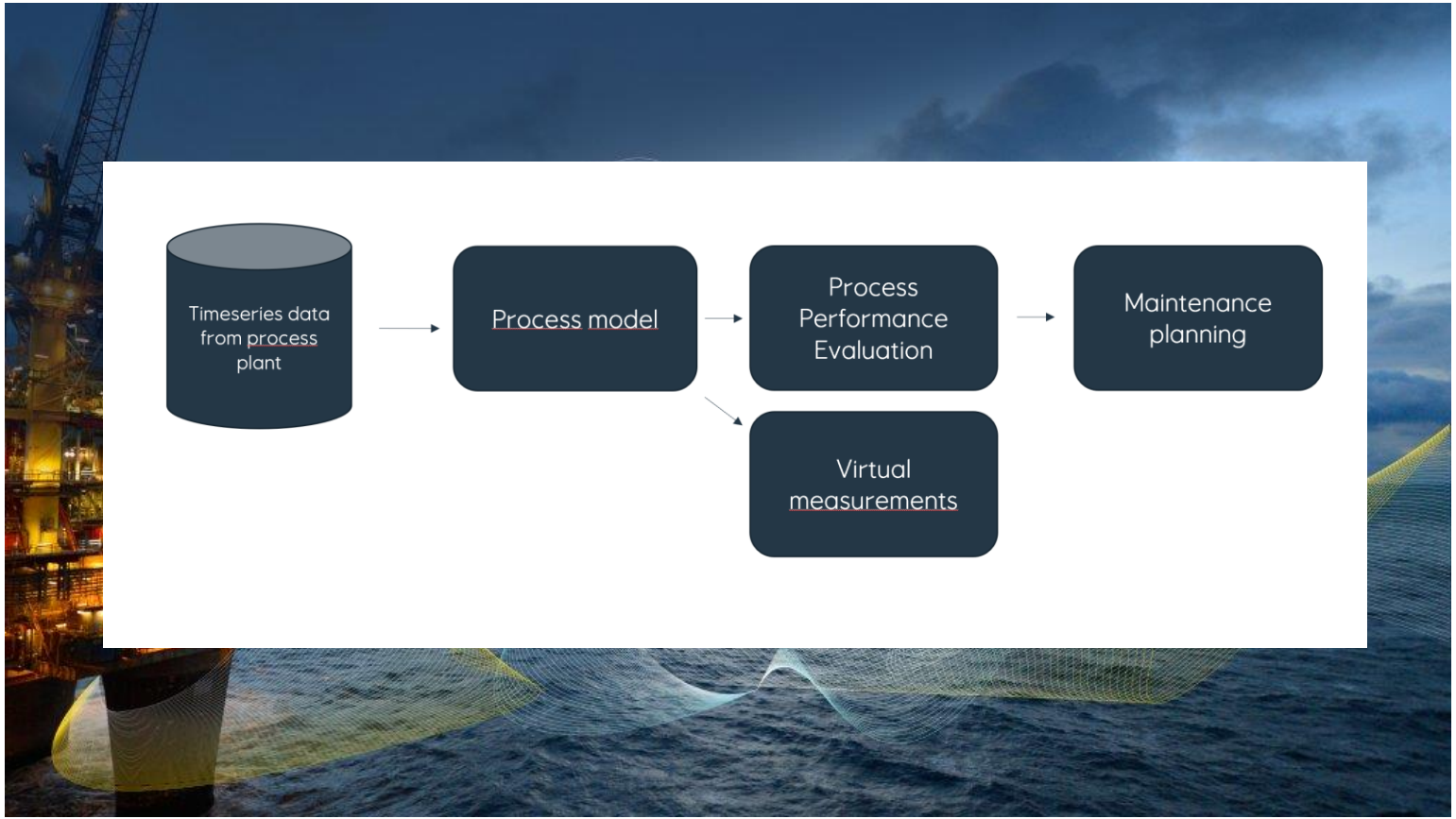
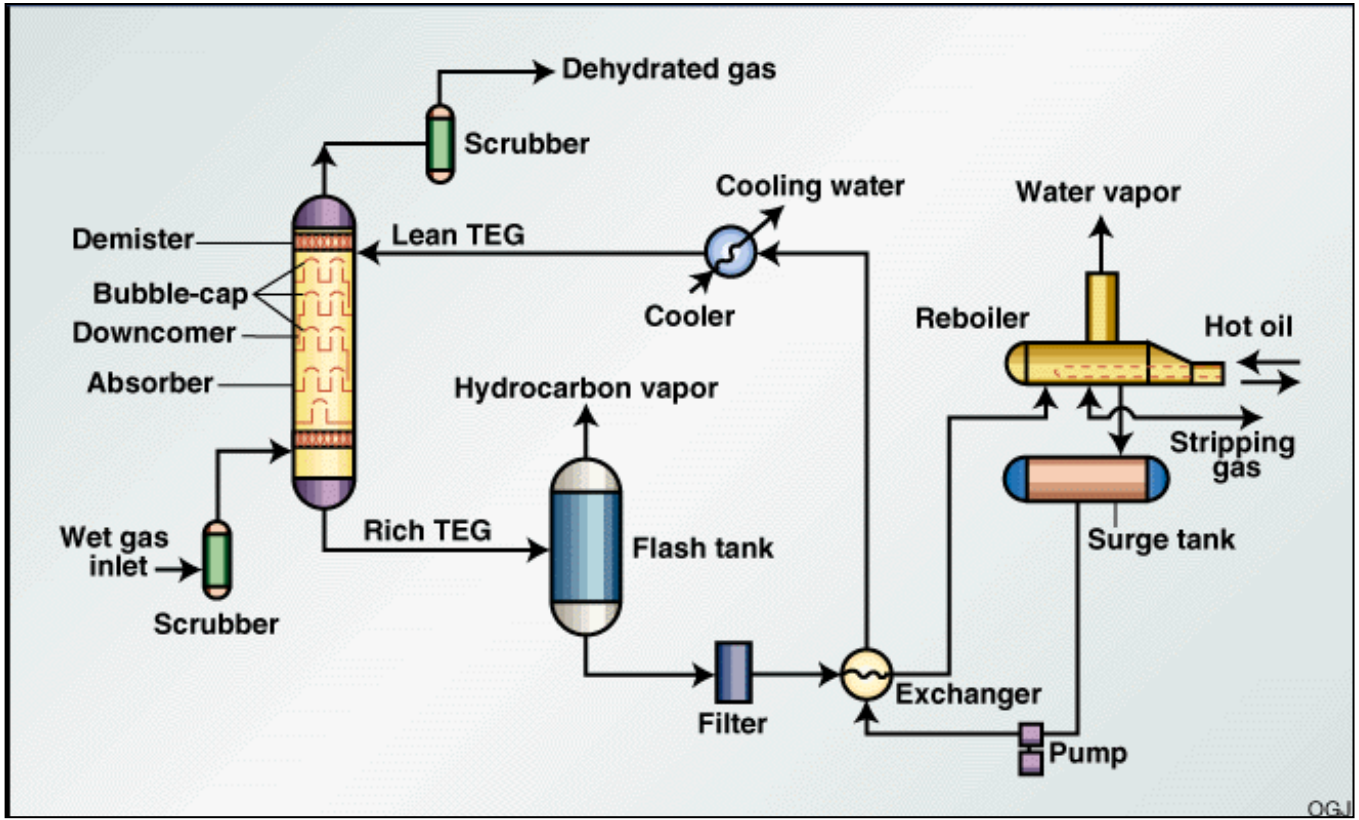


Figure: The Krafla field development

The NeqSim Digital Twin for Gas Processing



Process monitoring of a TEG dehydration process



Virtual measurement of water in dry gas

Blue: process simulator

Orange and purple: instrument1/intrument2

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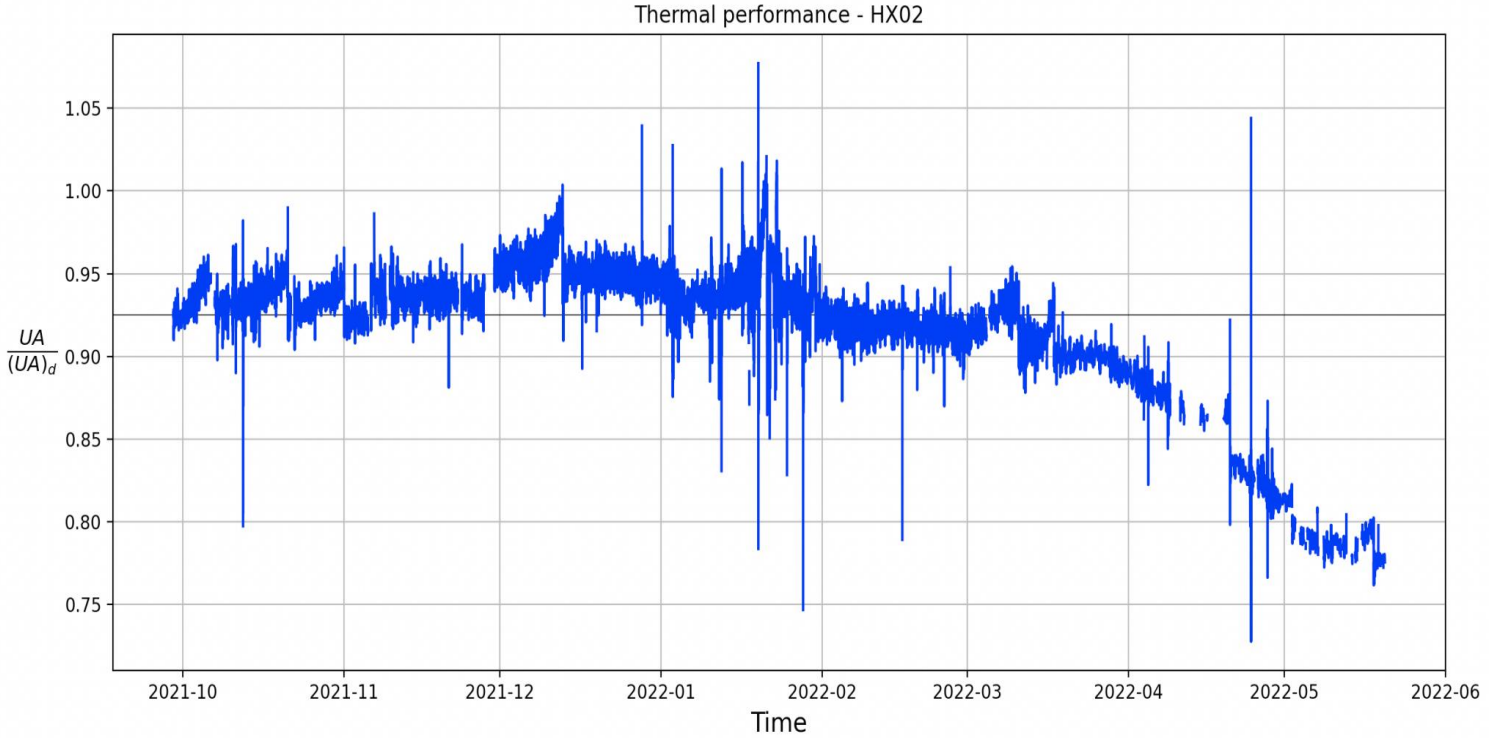
Henriette Sørbotten, Condition monitoring of TEG dehydration processes, master thesis, EPT, NTNU, 2021

Performance monitoring of heat exchangers



Y-axis: relative performance of heat exchanger

Trym Øksenvåg, Online condition monitoring of heat exchangers in a TEG dehydration process, master thesis, EPT, NTNU, 2022

Future gas value chains