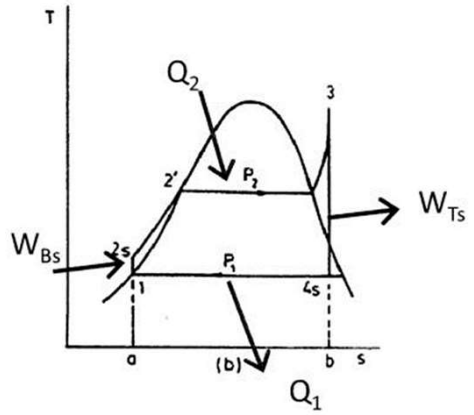
Organic Rankine Cycle (ORC). Huelva LNG Terminal

29th May/ Groningen

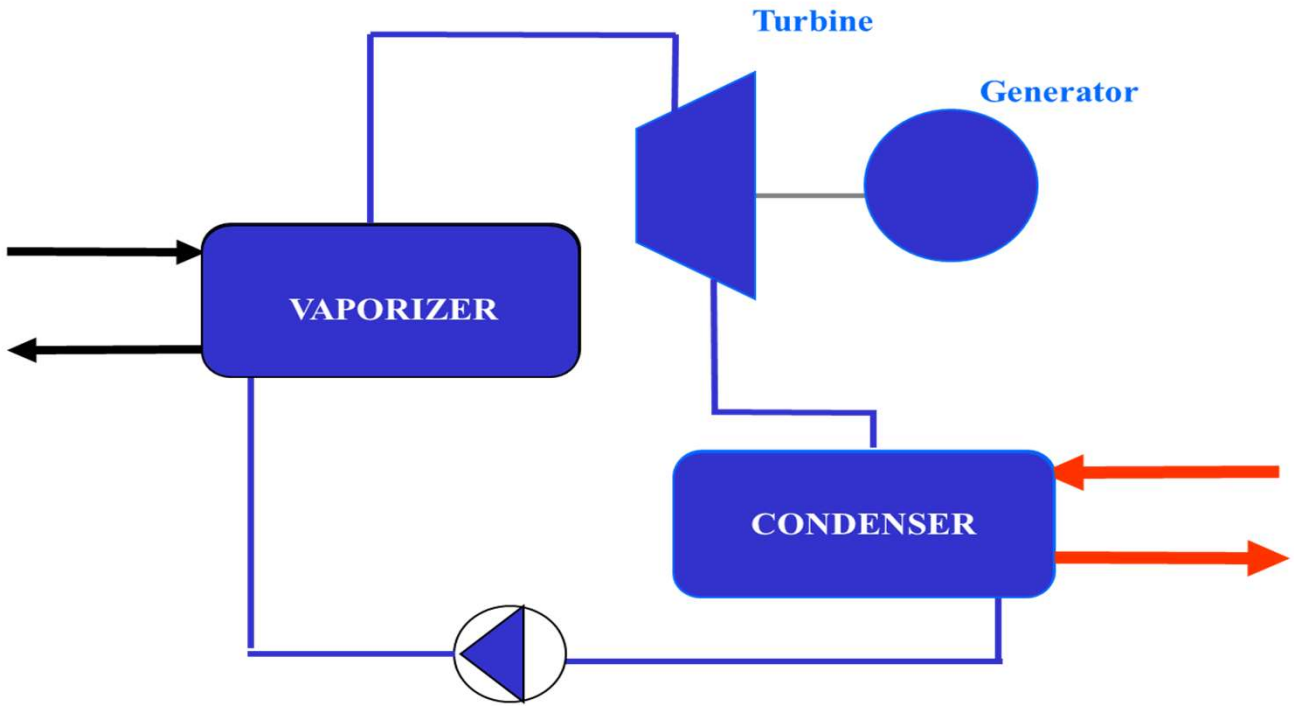
INTRODUCTION

- The objetive of this project is electric power generation making use of LNG physical exergy.
- Electric power generation is based on an Organic Rankine Cycle (ORC), which uses LNG as a cold source and sea water as a hot one.
- The project is a pilot production electric power plant with Ormat Energy Converter (OEC).
- Connection to Electrical Net in Jun 2012.
- In 2018, a cycle modification was implemented



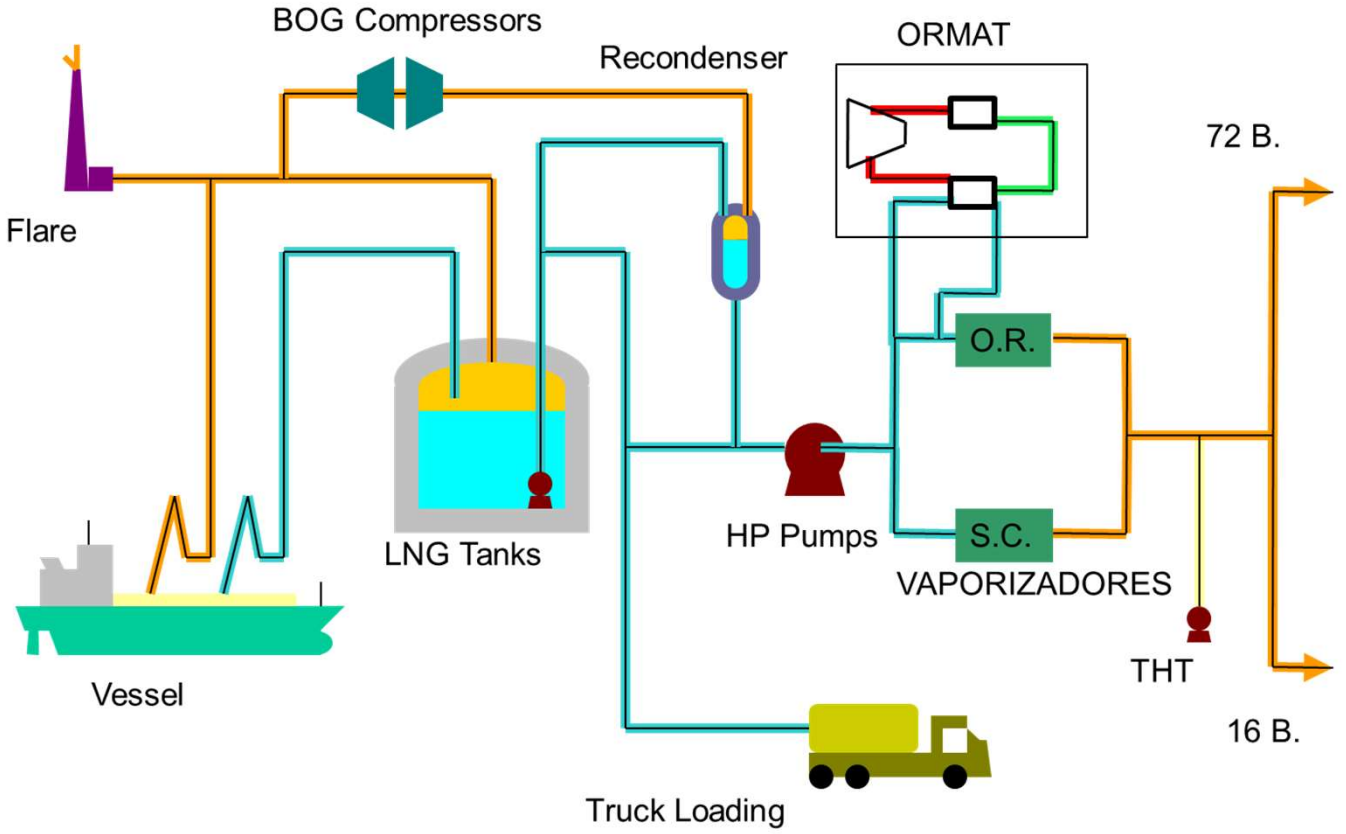
INTRODUCTION

ORGANIC RANKINE CYCLE SCHEME



INTRODUCTION

PROCESS DIAGRAM



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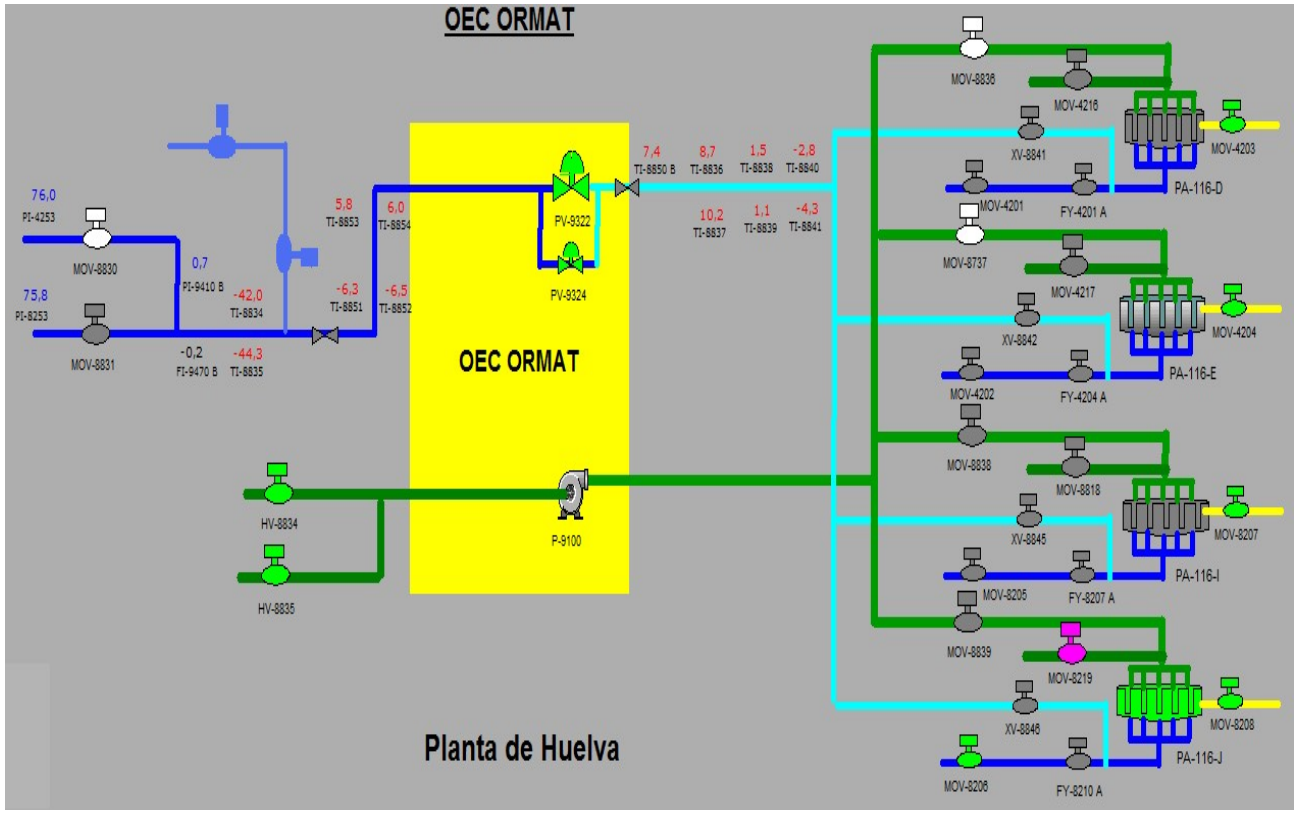


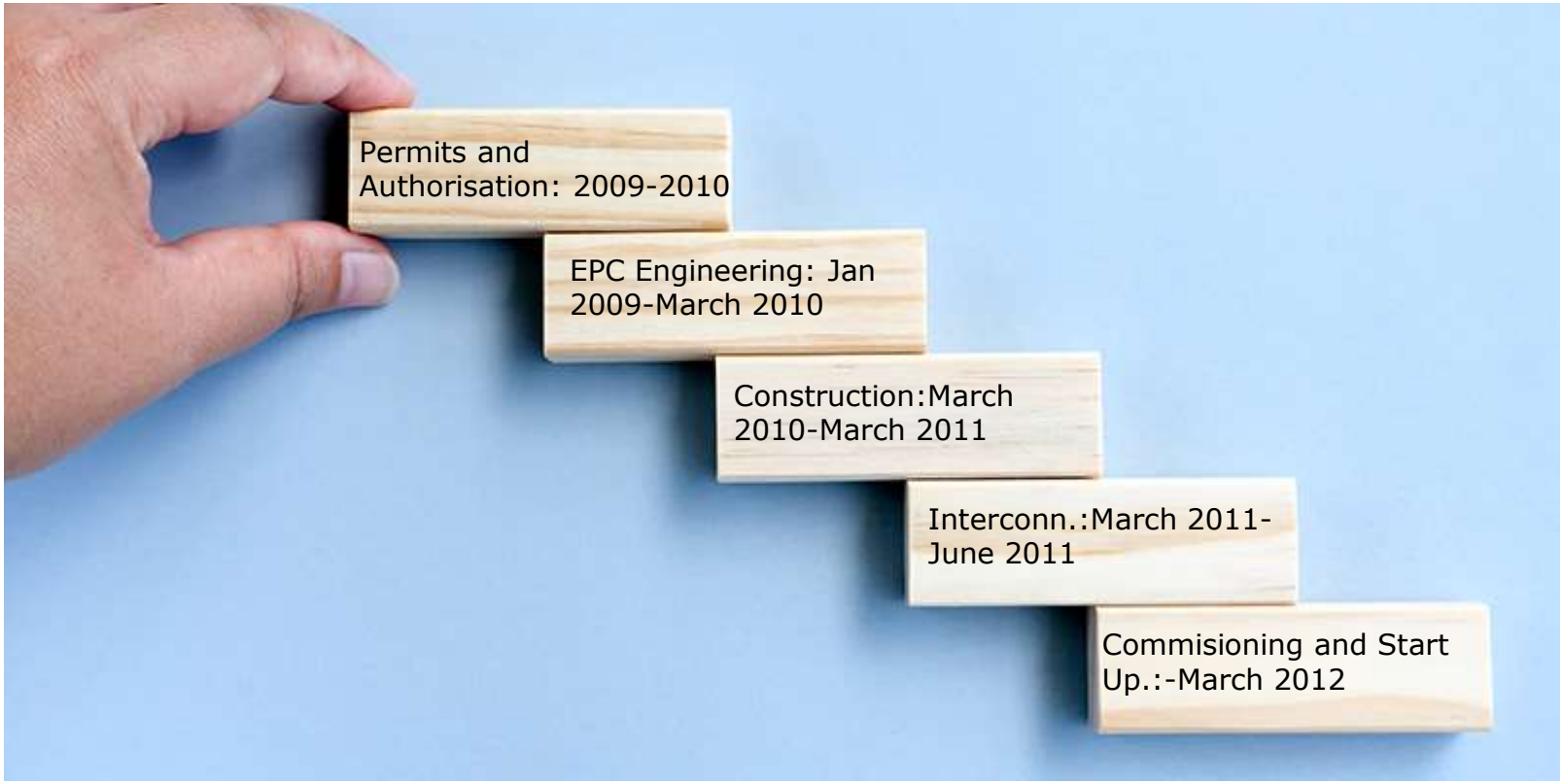
1. Introduction

2. Construction phase

3. Technical and operational data

CONSTRUCTION PHASE

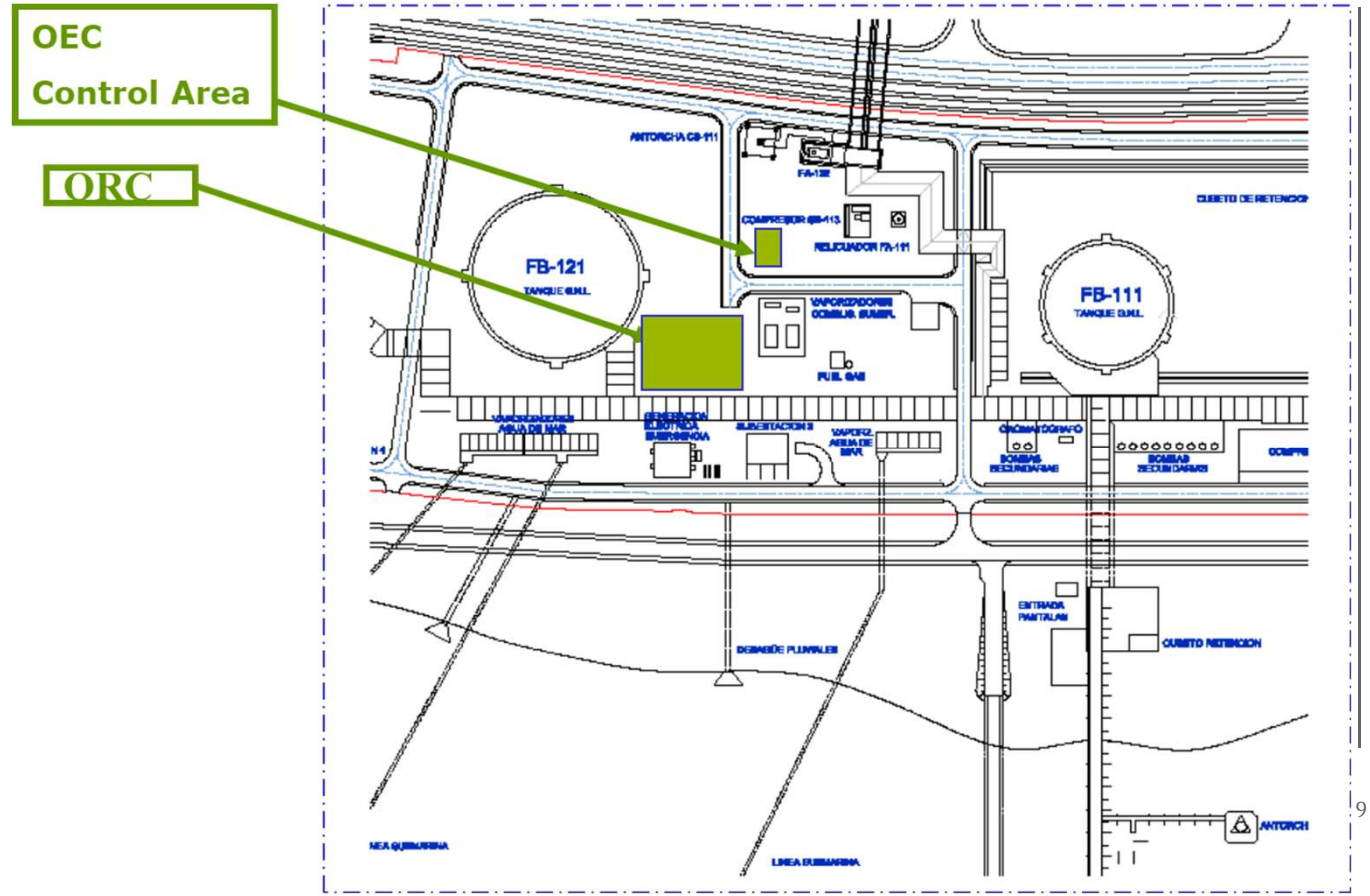
Project Schedule



CONSTRUCTION PHASE

SELECTED AREA

- Short distance between OEC system and Enagás equipment.
- Small pressure drops values
- Flexibility of operation with OEC and ORV



CONSTRUCTION PHASE

View from Tank FB111

CONSTRUCTION PHASE

View from Tank FB121

CONSTRUCTION PHASE

CONSTRUCTION PHASE

ORC Control Room

CONSTRUCTION PHASE

Turbine

CONSTRUCTION PHASE

GENERAL VIEW

CONSTRUCTION PHASE

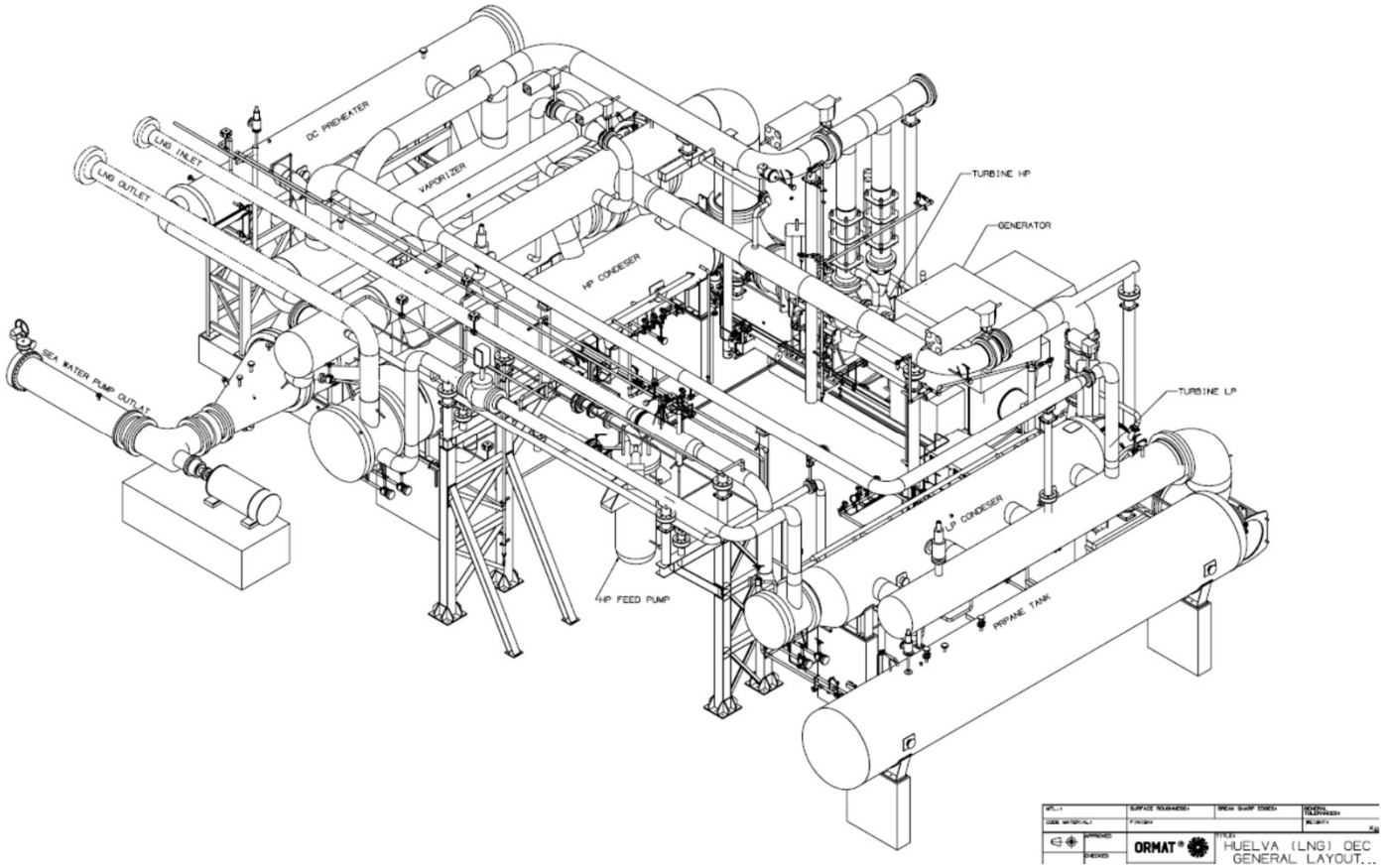
GENERAL VIEW

CONSTRUCTION PHASE

GENERAL VIEW

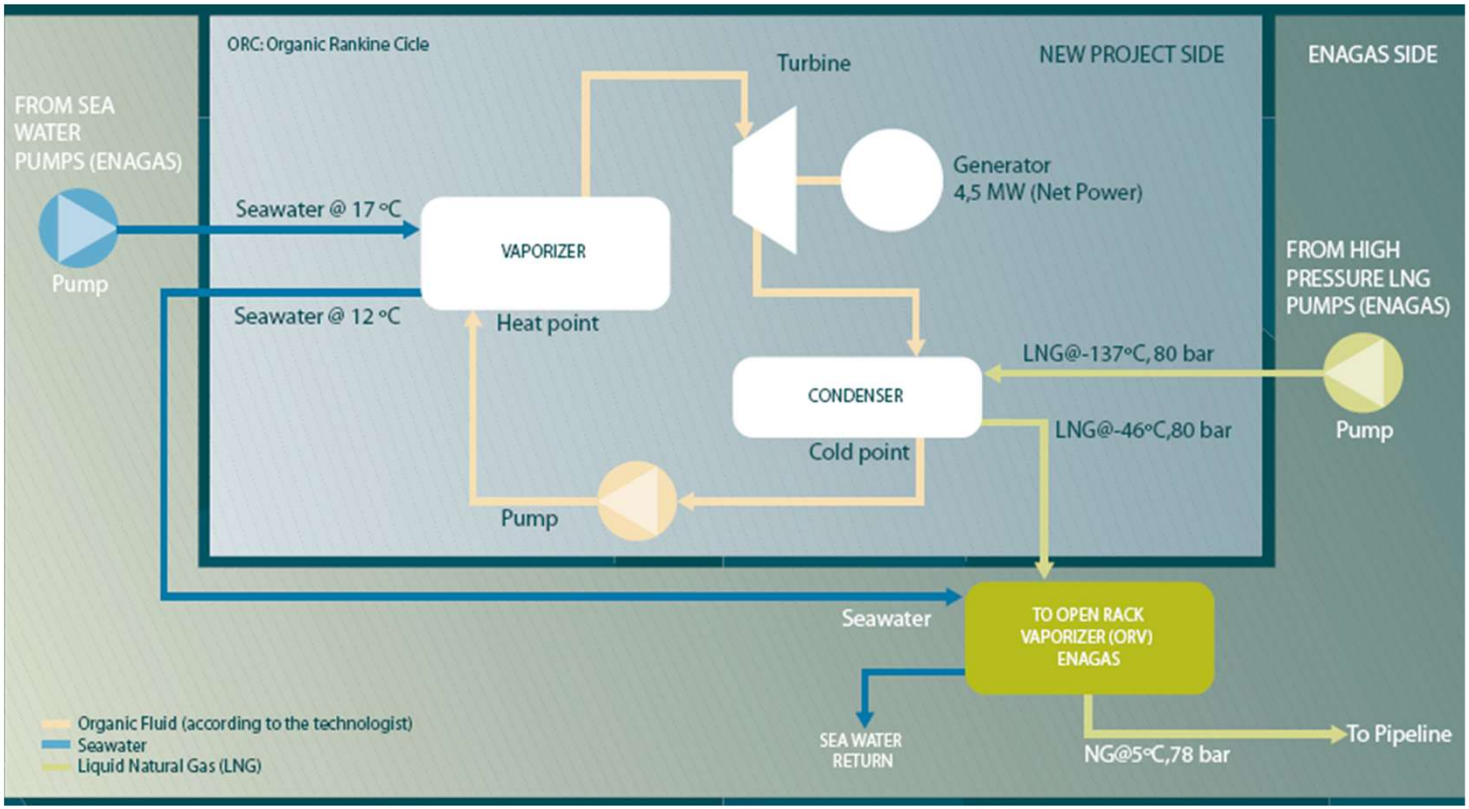
CONSTRUCTION PHASE

LAYOUT

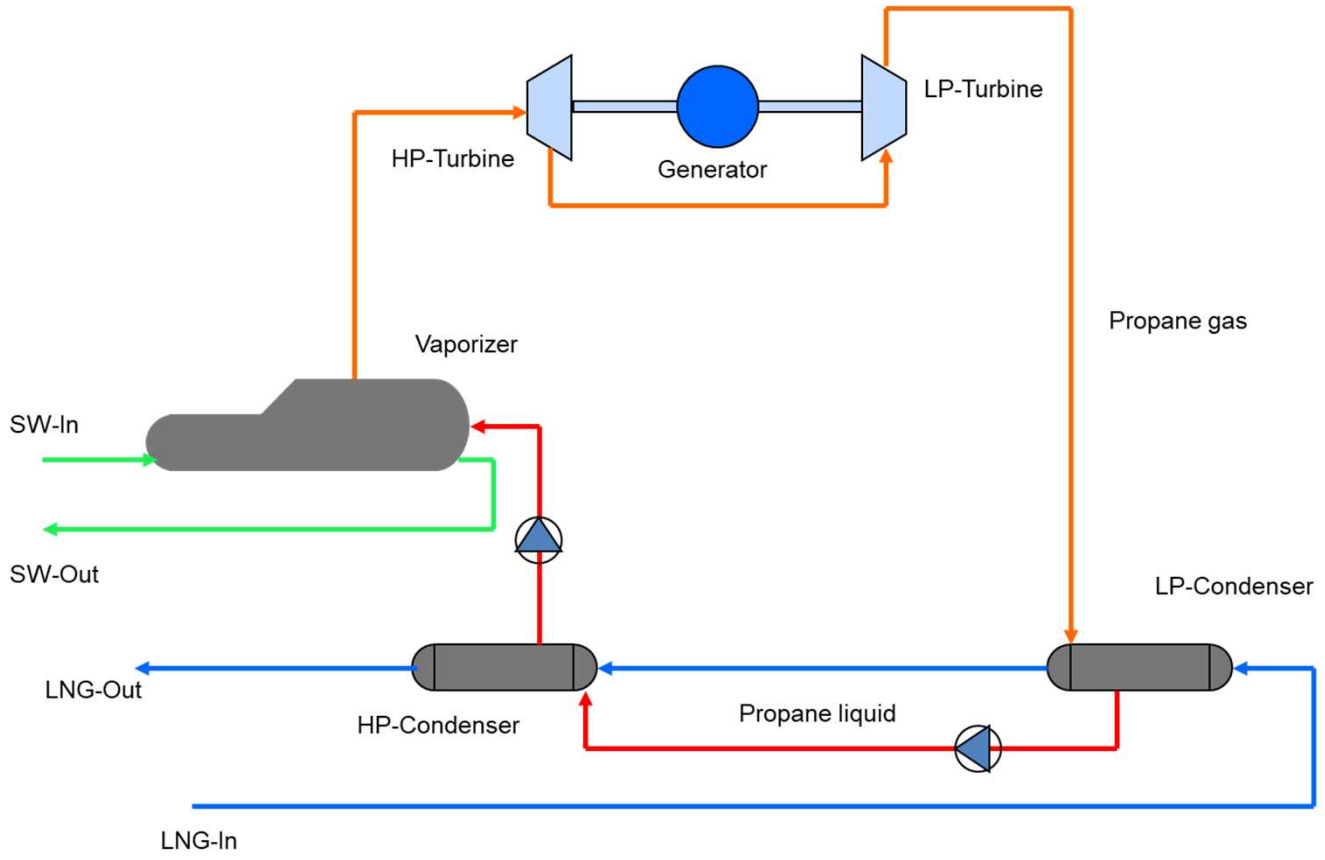


1. Introduction
2. Construction phase
3. **Technical and operational data**

TECHNICAL AND OPERATIONAL DATA



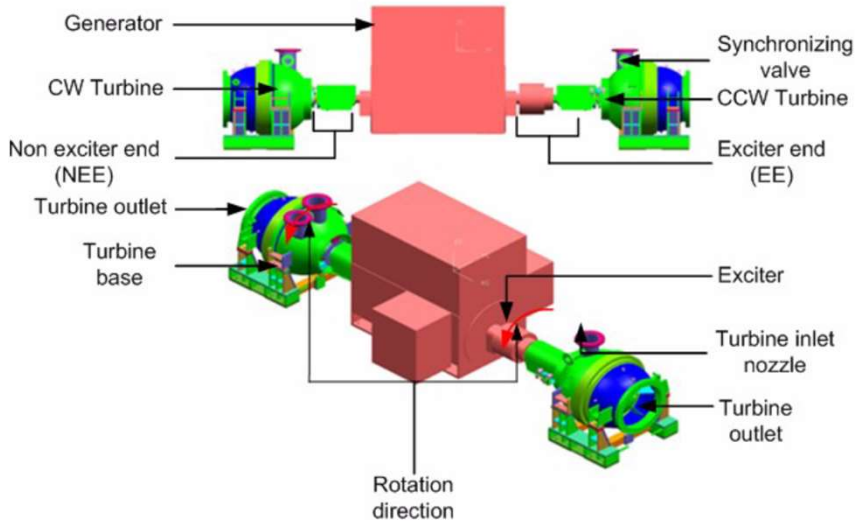
TECHNICAL AND OPERATIONAL DATA



TECHNICAL AND OPERATIONAL DATA

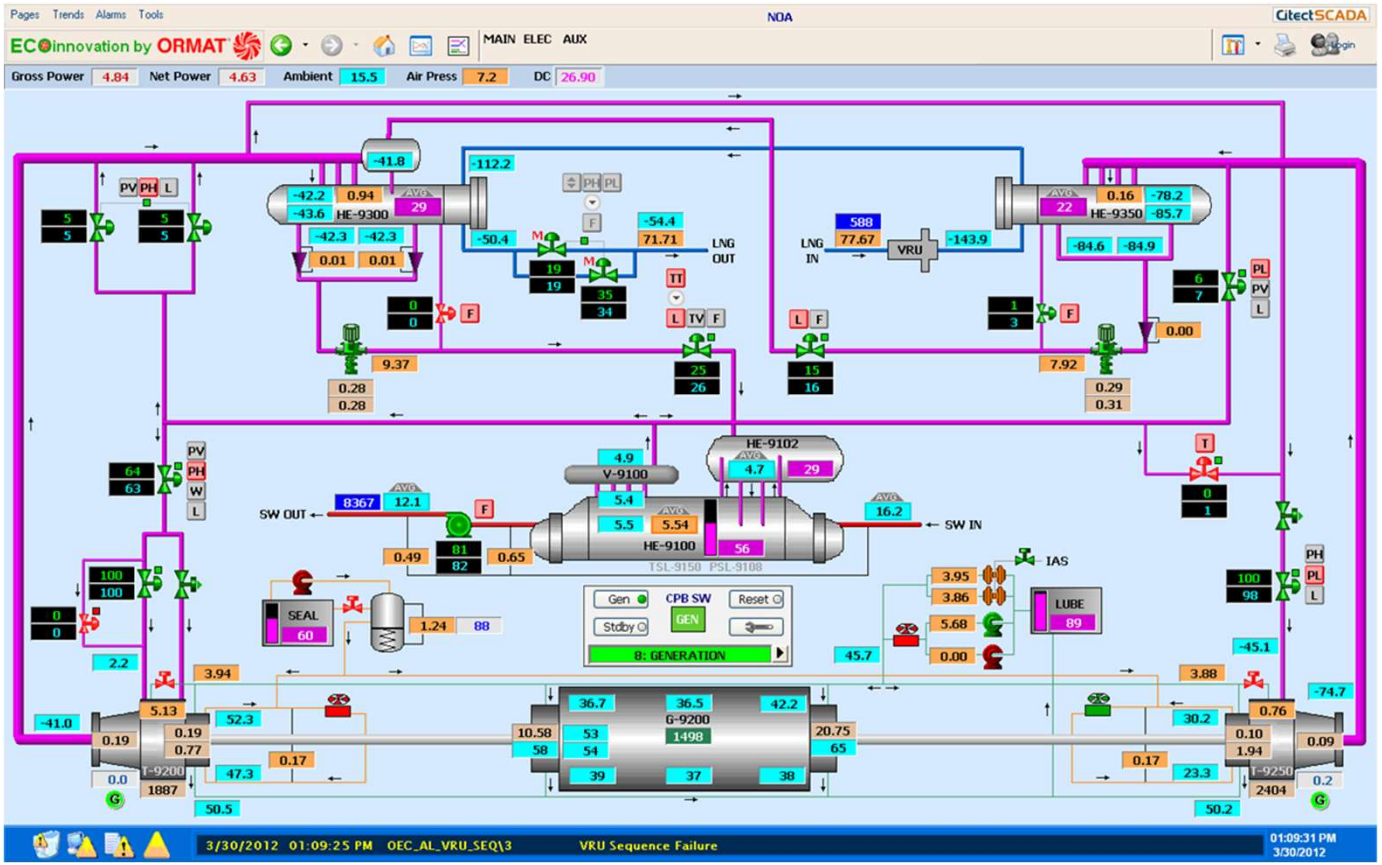
Technical data

- ✓ GROSS POWER : 5.140 kW/h
- ✓ NET POWER: 4.500 kW/h
- ✓ GENERATED NET ENERGY: 29.565 MWh/y
- ✓ ANUAL TIME WORKING : 7.000 hour
- ✓ PILOT PLANT DIMENSIONS : 25 m x 25 m
- ✓ AUTO-CONSUMPTION : 4.200 MWh/y
- ✓ LNG FLOW : 600 m3/h
- ✓ SEAWATER FLOW : 8.000 m3/h
- ✓ TURBINE SPEED : 1.500/1.800 rpm



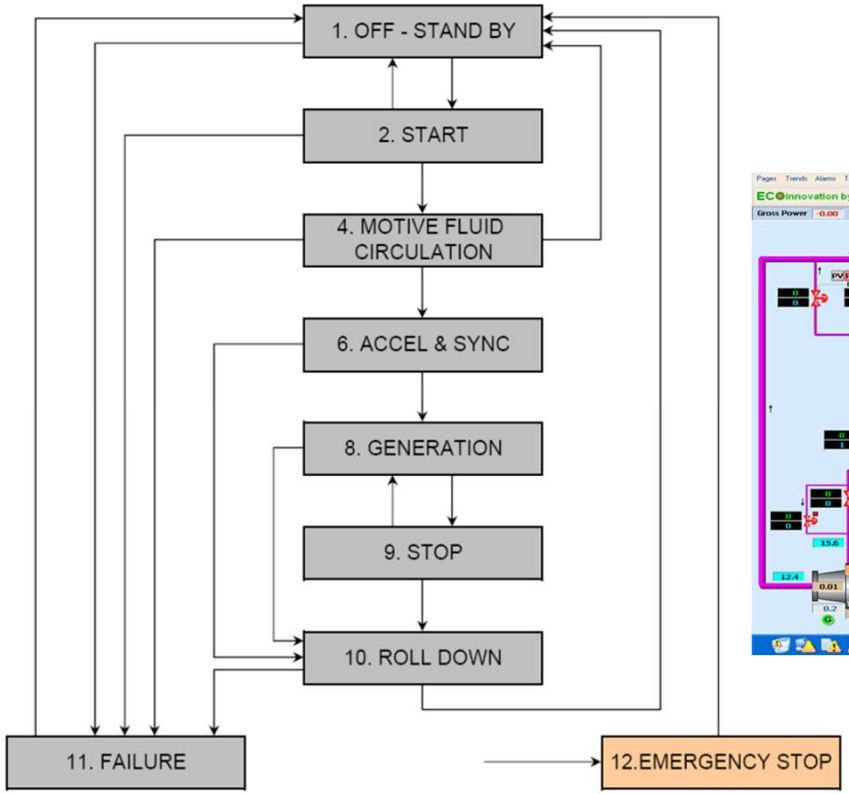
TECHNICAL AND OPERATIONAL DATA

Original Designed

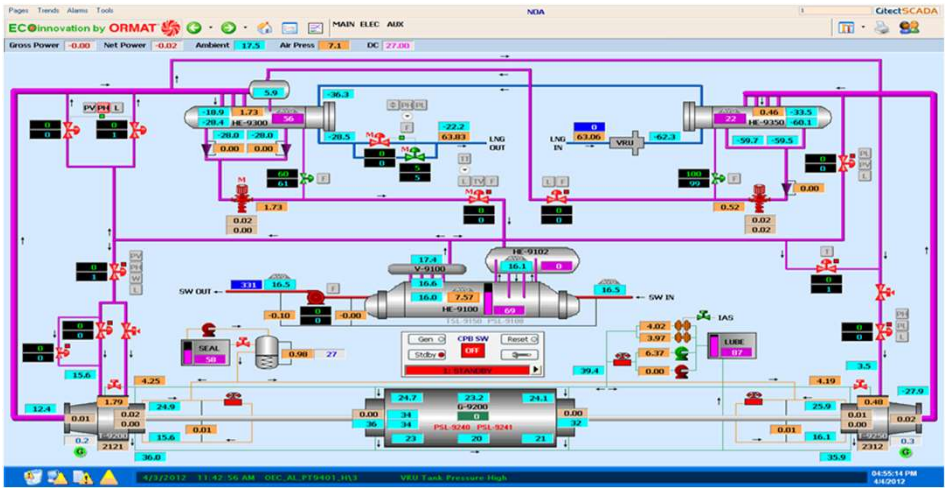


TECHNICAL AND OPERATIONAL DATA

Start-up sequence



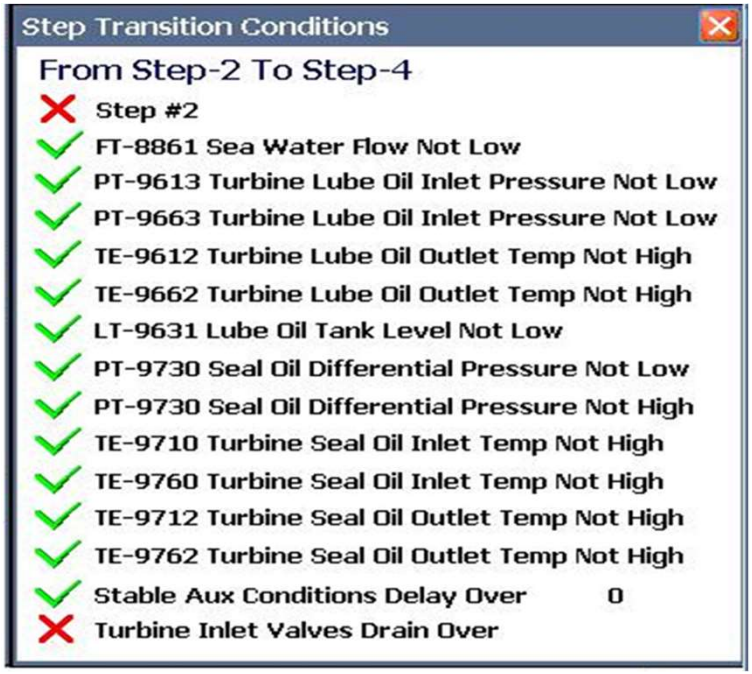
The start/stop of the NOA OEC plant is controlled by a PLC that initiates a sequence of steps once the operator presses START/STOP.



TECHNICAL AND OPERATIONAL DATA

Start-up sequence

STEP 2 "COMMISSIONING THE AUXILIARY SYSTEMS".
The position of the valves is the same as in step 1.
Start of the boot sequence with the activation of:
Start-up of the lubrication system.
An opening/closing test of the turbine valves is carried out.
Oil pressure and temperature OK
Turbine valve test OK
Stable conditions for 1 minute.
Proceed to step 4 "MF circulation".



RECOVERED ENERGY GENERATION SYSTEM

Start-up sequence

STEP 4. MF CIRCULATION:
The MF gradually passes through the bypass valves of the turbines. The turbines are not working yet and the generator is not connected to the grid. This process continues until the pressure, temperature, level and flow values stabilize within the established parameters.

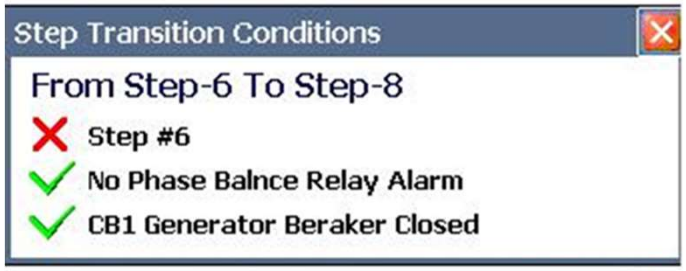
If the LNG flow rate is 80% above the set point for 5 minutes, then you go to step 6 “Acceleration and SYNCHRONIZATION”.

TECHNICAL AND OPERATIONAL DATA

Start-up sequence

STEP 6. ACCELERATION AND SYNCHRONIZATION
While the MF passes through the bypasses, the inlet valves to the turbines open. The turbines begin to rotate and accelerate to reach synchronization speed. This step is completed when the generator is coupled with the grid.
The conditions that must be met to move to the next generation step are:

STEP 8. GENERATION:
If the generator is coupled with the network, go to step 8 "GENERATION". If STOP is pressed or a fault appears, go to step 10 "DECELERATION". This is the main step of ORMAT operation. The closing of switches and coupling with the network occurs to produce the current. If "trigger" occurs, proceed to step 10 "DECELERATION.

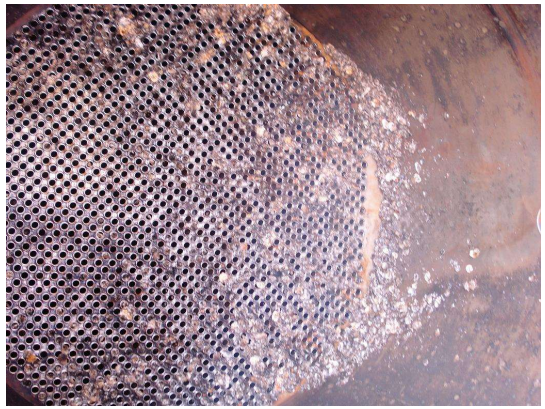


TECHNICAL AND OPERATIONAL DATA

OPERATIONAL PROBLEMS

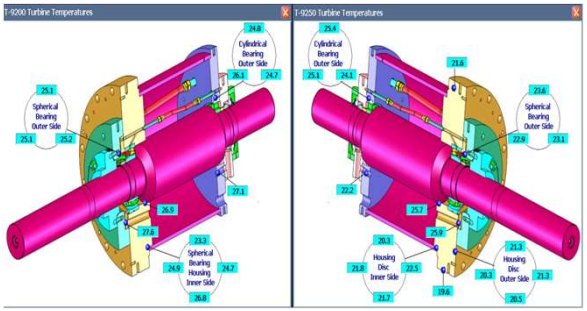
✓ Unstable performance:

The low pressure and high pressure cycles do not operate smoothly together.
Causing numerous trips during the operation.
Once the trip is generated , the propane gets cold very fast and It is difficult to avoid it. Long time until restart.



✓ Low pressure condenser and turbine designed:

The outlet of the LP Turbine goes into the LP Condenser in the mid point.
Level control is critical: liquid to the turbine causing trip and failure (difficult to remove)



✓ Seawater inside tubes: H deltaP problems, fouling.

- ✓ Seawater filter was installed

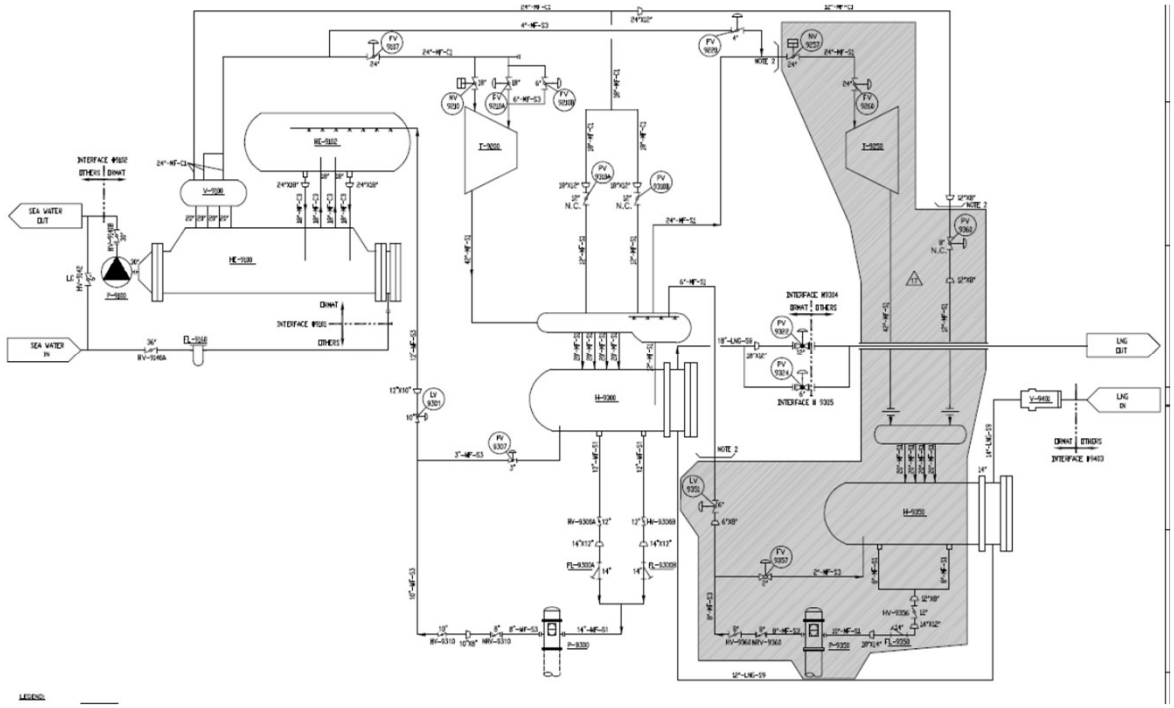
✓ Reduced life expectancy of the Propane LP an HP pumps

TECHNICAL AND OPERATIONAL DATA

REDESIGN(2018)

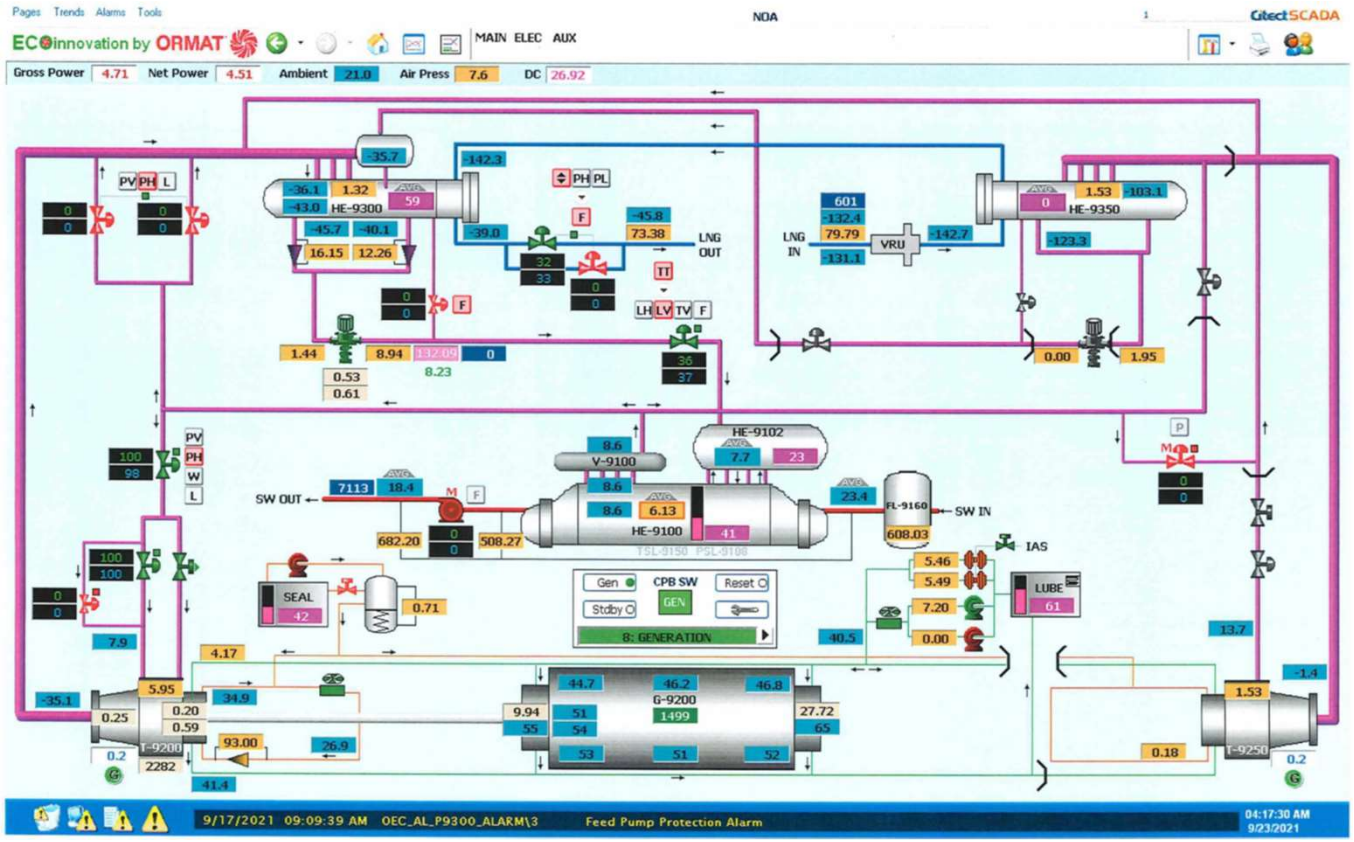
The suggested plant modification covers several sections as follow:

- LP turbine isolation.
- LP condenser isolation.
- VRU system changes.
- Propane storage tank changes.
- Fill & Drain system changes.
- HP condenser area changes.



TECHNICAL AND OPERATIONAL DATA

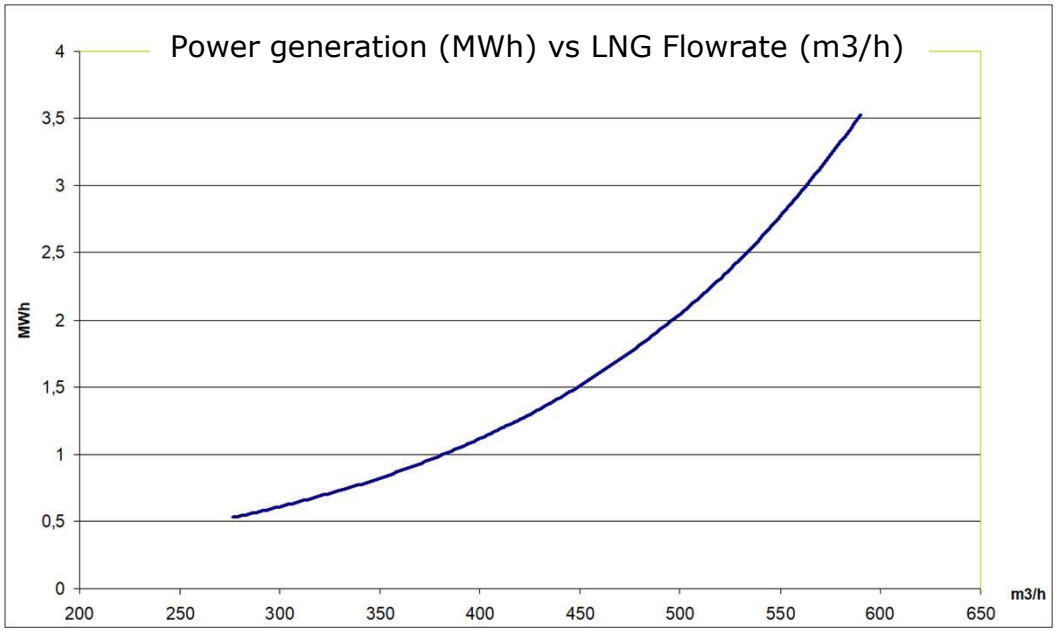
Plant Modification to single Cycle



TECHNICAL AND OPERATIONAL DATA

REAL EFFICIENCY

- Electrical generation versus LNG flow follows an exponential behavior. If an LNG flow is decreased a little below the Nominal, this considerably affects the electrical performance. Going down from 580 m3/h of LNG (maximum step II) to 480 m3/h (minimum step II) implies generating 1 MWh less.



TECHNICAL AND OPERATIONAL DATA

Energy generated data

- Historical data from 2019 (after redesigned) and zoom in 2022.
- 2023: low send-out and Propane pump replacement.

	Energy Generated (Mwh)
2019	**19.599,28**
2020	**25.359,93**
2021	**17.493,07**
2022	**21.047,68**
2023	**11.208,63**
Total general	**94.763,60**

Ormat Energy Saving.

2.022	*Elec. Consumption Terminal (MWh)*	*ORMAT Energy Saving(MWh)*	*%*	*Tn CO2 Equi*
January	6.335	1.396	22,04%	259,27
February	4.575	1.567	34,24%	291,01
March	5.469	2.477	45,28%	460,45
April	4.402	2.045	46,47%	380,45
May	4.902	1.485	30,30%	275,62
June	5.675	2.174	38,31%	403,86
July	5.643	2.646	46,89%	492,01
August	4.928	1.180	23,95%	218,53
September	5.470	2.568	46,94%	477,50
October	5.047	1.001	19,84%	185,45
November	6.527	929	14,23%	170,71
December	5.786	1.579	27,29%	293,02
Total general	**64.760**	**21.047**	**32,50%**	**3.907,89**

Thank
you