Visual MESA® Multi-Period Optimizer with all Renewables
Visual MESA Hybrid Power Plant Digital Twin

A Yokogawa Company

Example

How the Hybrid Power Plant should be operated during the day, in order to maximize overall profits?

- Supplying the promised power to the grid
- Satisfying the Green Hydrogen demand

A Multi-Period Optimization was performed with the Visual MESA Multi-Period Optimizer application

- Based on forecasts for weather (wind, solar radiation, ambient temperature) and power grid prices during the upcoming day
- In order to define the:
    - Optimal batteries power inventory (i.e. when to charge and discharge)
    - Optimal Green Hydrogen management that includes:
        - Electrolyzer (PEM) operation (i.e. when to produce Green Hydrogen with power and demineralized water)
        - Storage management for both, Green Hydrogen and Oxygen (by-product), including compression power
        - Fuel Cell operation (i.e. when to produce electricity by using the stored Hydrogen and Oxygen)

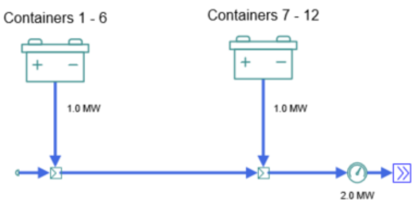
Visual MESA® Multi-Period Optimizer with all Renewables

Visual MESA Hybrid Power Plant Digital Twin Example – Optimal Batteries Schedule

KBC
A Yokogawa Company

BATTERIES

Visual MESA EMS Demo



KBC A Yokogawa Company — **Hybrid Power Plant** — Report Version v04

VM-MPO Solution - Optimal batteries charge schedule

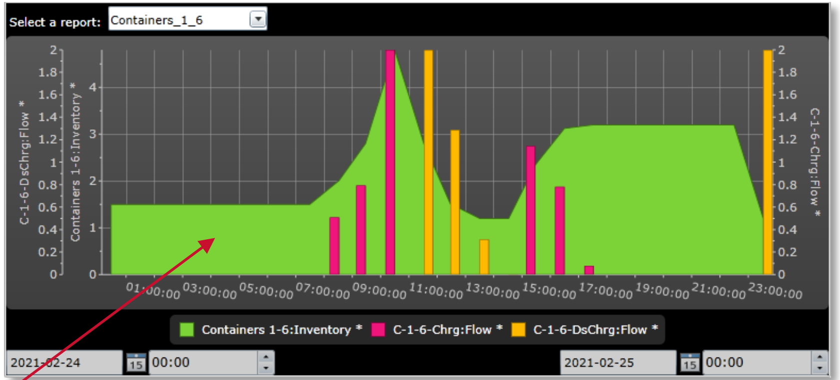
Start Time	02/24/2021 00:00:00
End Time	02/25/2021 00:00:00

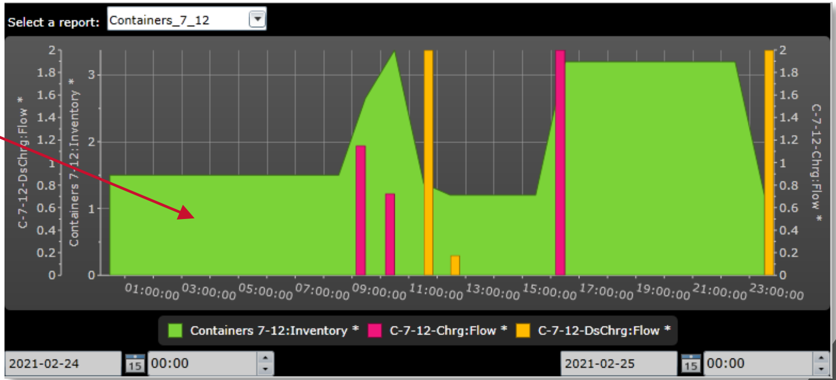
Hours

Batteries Containers 1-6	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22	22-23	23-0
Charging (MW)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.51	0.00	2.00	0.00	0.00	0.00	0.00	1.14	0.78	0.08	0.00	0.00	0.00	0.00	0.00	0.00
Discharging (MW)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00	0.50	0.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00
Containers 1-6 charge (MWh)	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	2.01	2.01	4.01	2.01	1.51	1.20	1.20	2.34	3.12	3.20	3.20	3.20	3.20	3.20	3.20	1.20

Hours

Batteries Containers 7-12	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22	22-23	23-0
Charging (MW)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.94	0.72	0.00	0.00	0.00	0.00	0.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Discharging (MW)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00	0.97	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00
Conrtainers 7-12 charge (MWh)	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	3.44	4.17	2.17	1.20	1.20	1.20	1.20	3.20	3.20	3.20	3.20	3.20	3.20	3.20	1.20
Total Batteries Charge (MWh)	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.51	5.45	8.17	4.17	2.71	2.40	2.40	3.54	6.32	6.40	6.40	6.40	6.40	6.40	6.40	2.40





Example

How batteries and Hydrogen Storage can be properly managed in order to maintain a certain maximum amount of power exported to the grid and maximize profits?

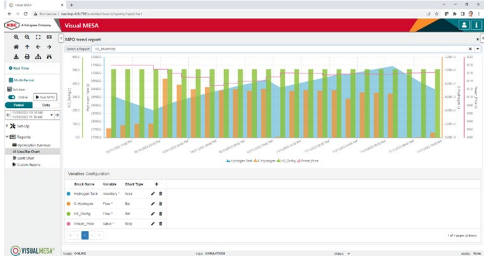
Visual MESA® Multi-Period Optimizer with all Renewables

Visual MESA Hybrid Power Plant Digital Twin

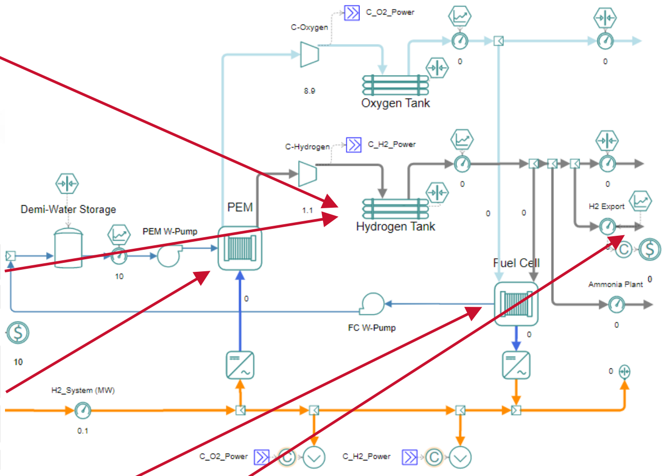
Example – Optimal Electrolyzer (Green Hydrogen Production), Storage and Fuel Cell Schedules

A Yokogawa Company

Optimal Hydrogen Tank Management (Green Hydrogen Storage)



Electrolizer/Fuel Cell
Visual MESA



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Hybrid Power Plant
Report Version v04

MPO Solution

Start Time	02/24/2021 00:00:00
End Time	02/25/2021 00:00:00

Hydrogen Storage	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22	22-23	23-0
Charging (kg/h)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24.1	26.4	26.6	17.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Discharging (kg/h)	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	0.0	0.0	0.0	0.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Storage (ton)	0.19	0.18	0.17	0.16	0.15	0.14	0.13	0.12	0.11	0.10	0.09	0.08	0.10	0.13	0.16	0.17	0.16	0.15	0.14	0.13	0.12	0.11	0.10	0.09

PEM Electrolyzer	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22	22-23	23-0
H2 Generation (kg/h)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24.1	26.4	26.6	17.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
O2 Generation (kg/h)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	195.3	213.2	215.6	144.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
H20 Consumption (kg/h)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	219.4	239.6	242.3	162.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
H2 Compressor Power (M'	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.04	0.04	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Electrolyzer Power (MW)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	1.49	2.64	2.80	0.96	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Overall Efficiency (%)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	64%	39%	38%	74%	0%	0%	0%	0%	0%	0%	0%	0%

Fuel Cell	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22	22-23	23-0
H2 Consumption (kg/h)	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	0.00	0.00	0.00	0.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
H20 Generation (kg/h)	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	0.00	0.00	0.00	0.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00
Power Generation (MW)	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.00	0.00	0.00	0.00	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
Efficiency (%)	47%	47%	47%	47%	47%	47%	47%	47%	47%	47%	47%	47%	0%	0%	0%	0%	47%	47%	47%	47%	47%	47%	47%	47%

Hydrogen Export	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22	22-23	23-0
H2 Export (kg/h)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
H2 Price ($/kg)	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00