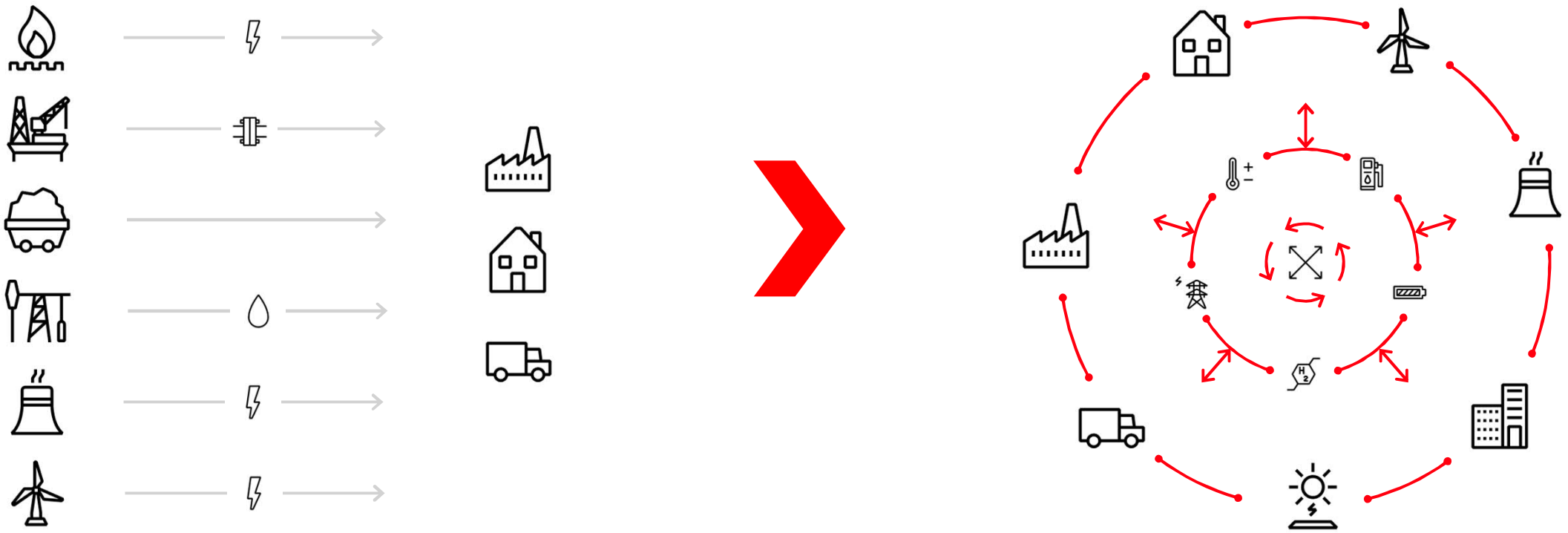
OPENMODELICA WORKSHOP, JANUARY 31, 2022

Use of OpenModelica in ABB OPTIMAX® for model-based control and optimization of sustainable energy systems

Dr. Rüdiger Franke

Energy landscape will change with the need of decarbonization

Transforming from linear, wasteful to integrated. With support of Hydrogen to close gaps.

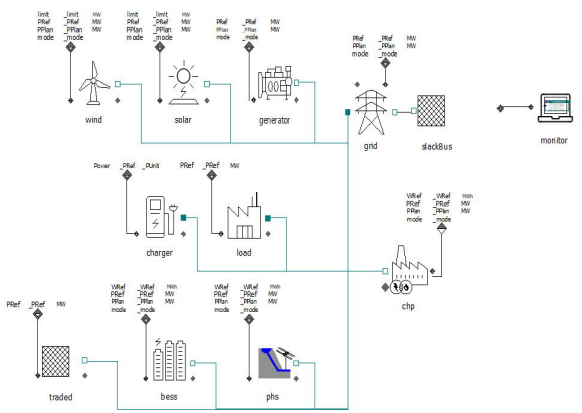


Maximize the value of used energy through high efficiency and synergies

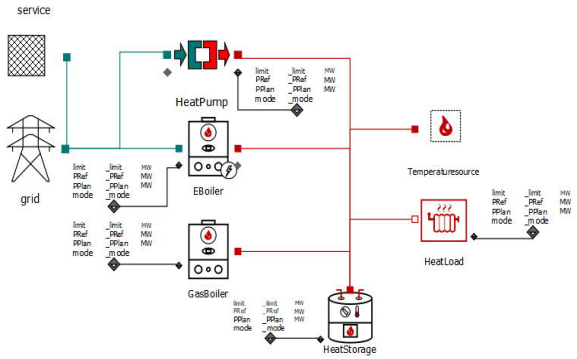
Virtual/Hybrid Power Plants with OpenModelica and OPTIMAX

Sector coupling with multiple domains

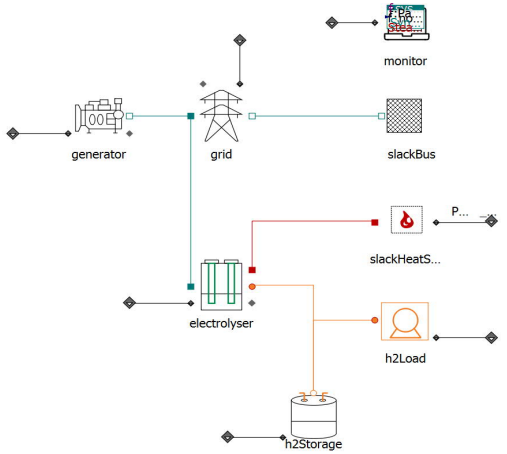
Electrical



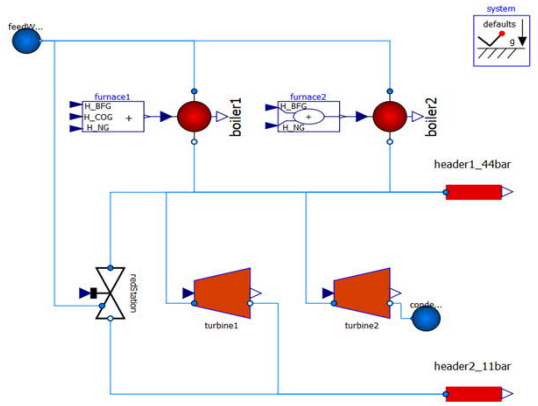
Thermal



Hydrogen



Steam



Master Integrated Energy Systems

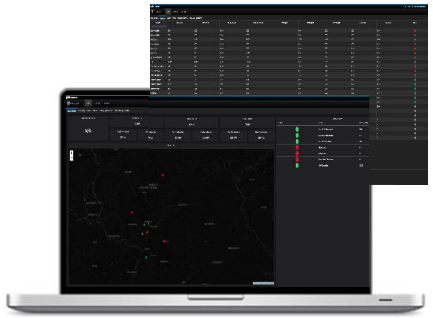
ABB Ability Energy Management

Building blocks

OPTIMAX® for Energy Management - Optimization and Control

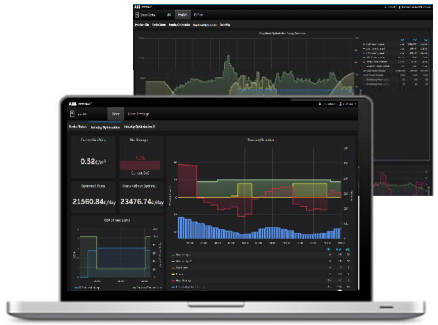
Energy / CO_2 Monitoring

- Make energy flows transparent
- Enhanced user experience and visibility of your energy usage



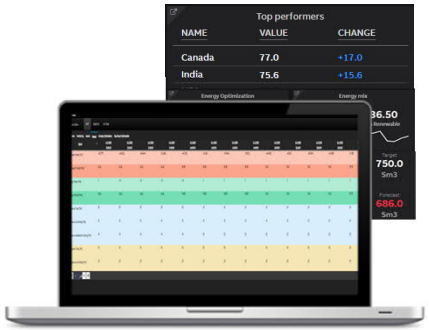
Real Time Operation

- Monitoring
- Optimal real-time control
- Schedule disaggregation
- Ancillary Service Calls
- Demand Response Calls



Intra-Day- / Day-Ahead-Optimization

- Optimally plan your portfolio
- Automatic rescheduling



Trading & Flexibility Indication

- Flexibility Indication
- Bidding Support

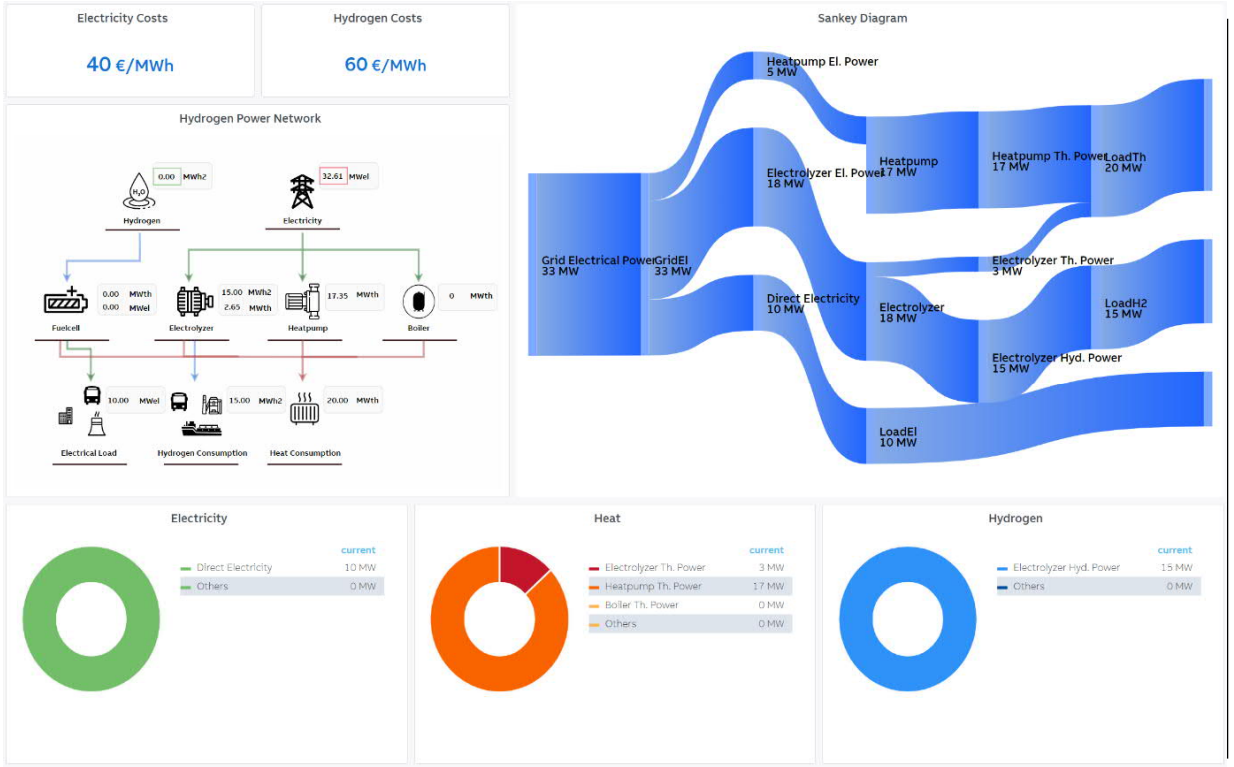
Reporting

- Easy to create reports and send production data to billing
- Per asset, per market, per customer, per type,…

OPTIMAX for Hydrogen Energy Management – Real-time optimization of plant set points

Fluctuating renewables result in time varying el prices that require varying operational regimes

Low prices scenario: PowerToX



High price scenario: exploit feed stock

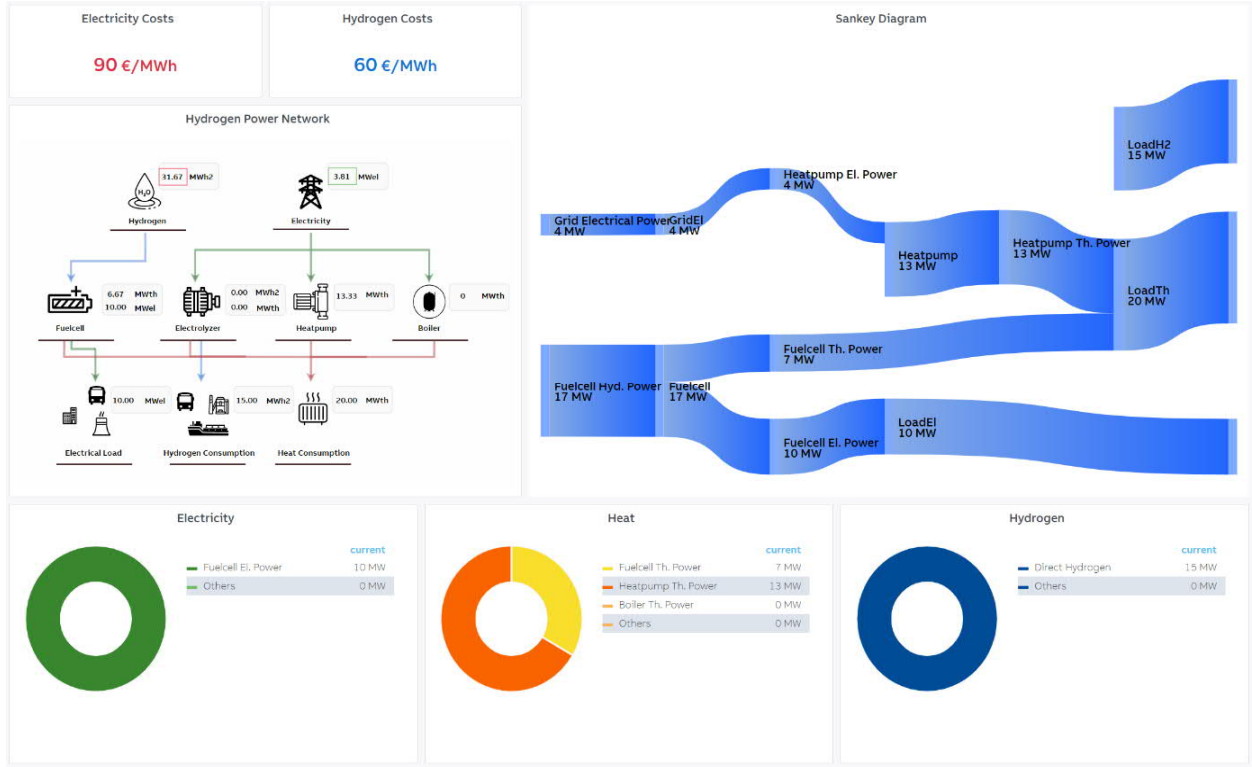
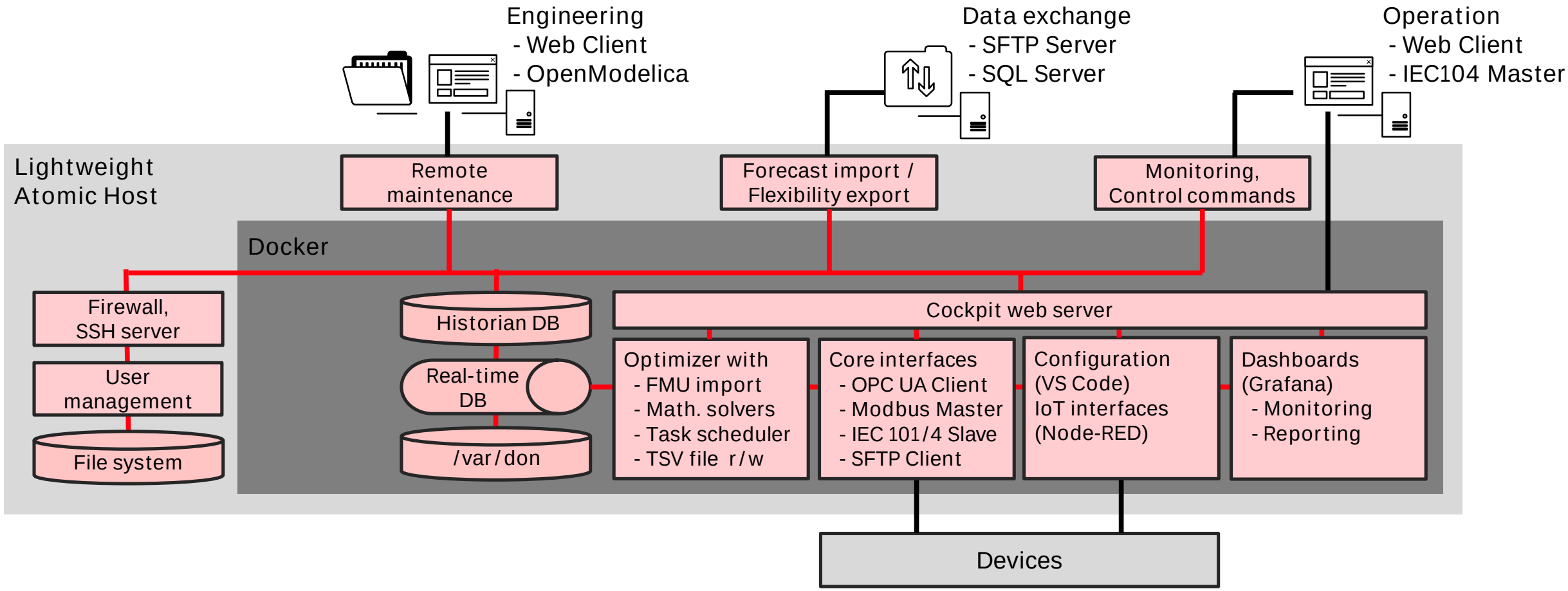


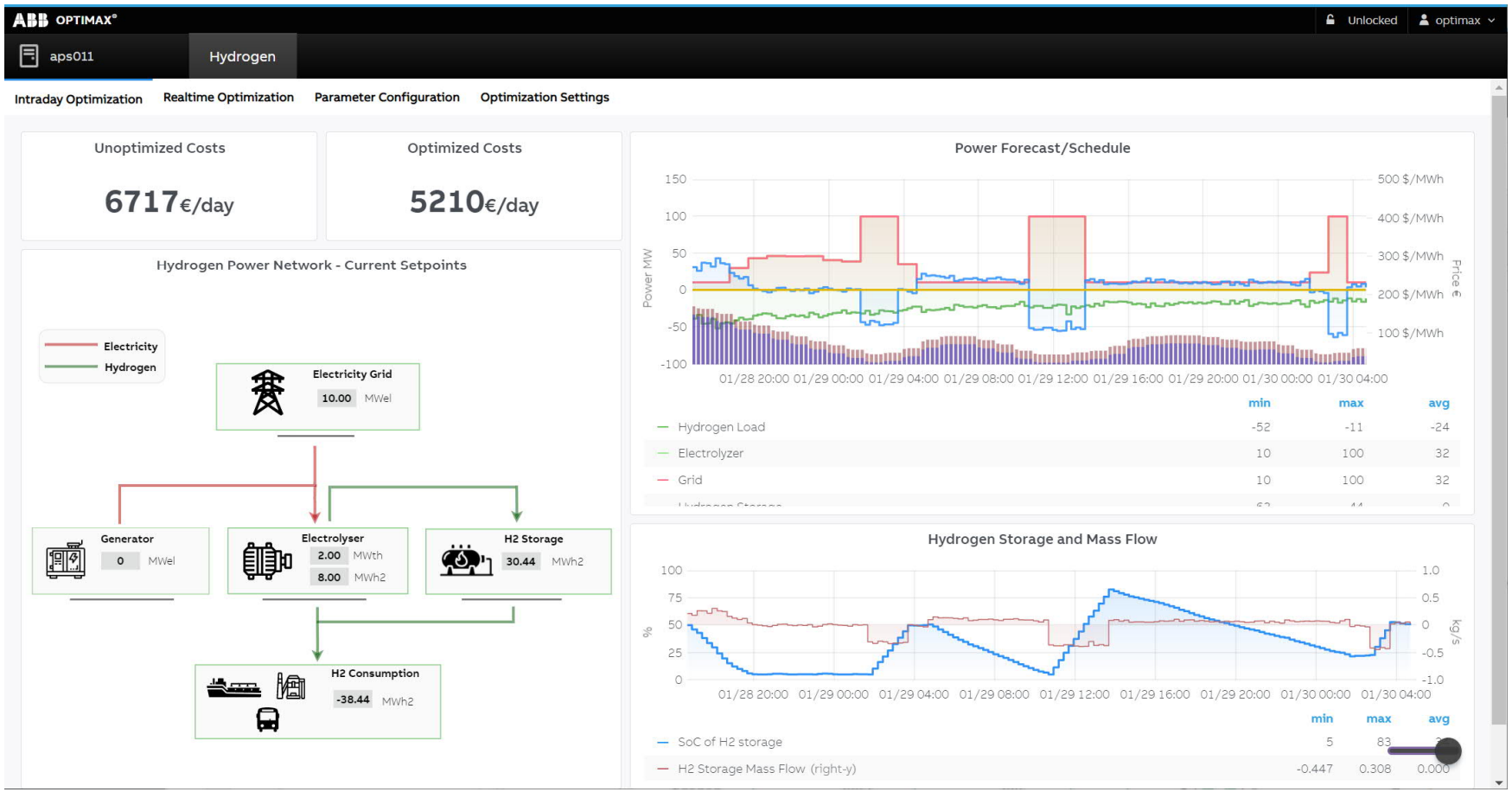
ABB OPTIMAX® – implemented with software containers

Empowers applications with best in class open technologies



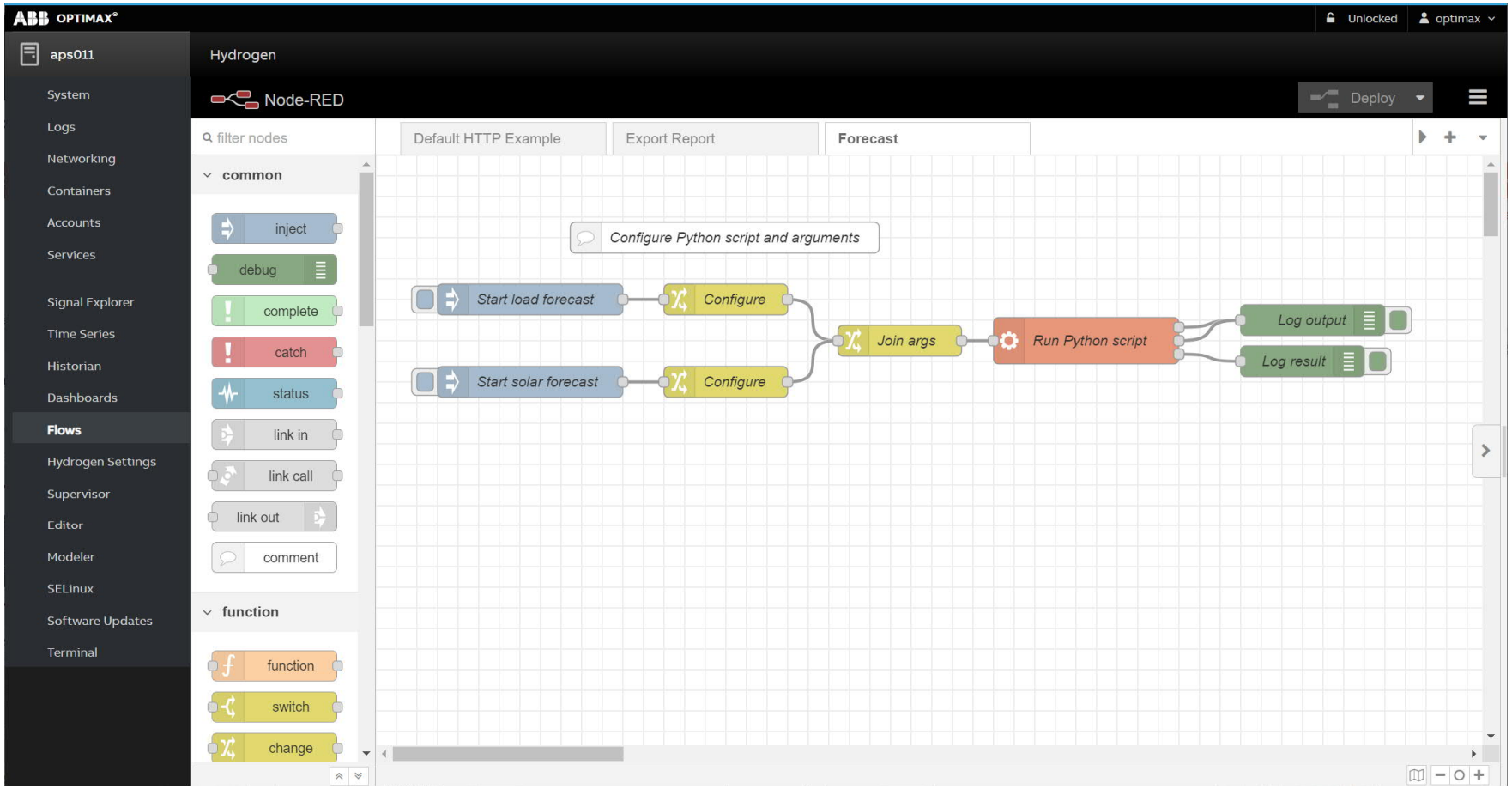
Cockpit UI

Integrating system management (left) and application dashboards (right)



IoT interfaces, customization and extensions with Node-RED

E.g. call Python routine for weather/load forecast



Low-code programming for event-driven applications

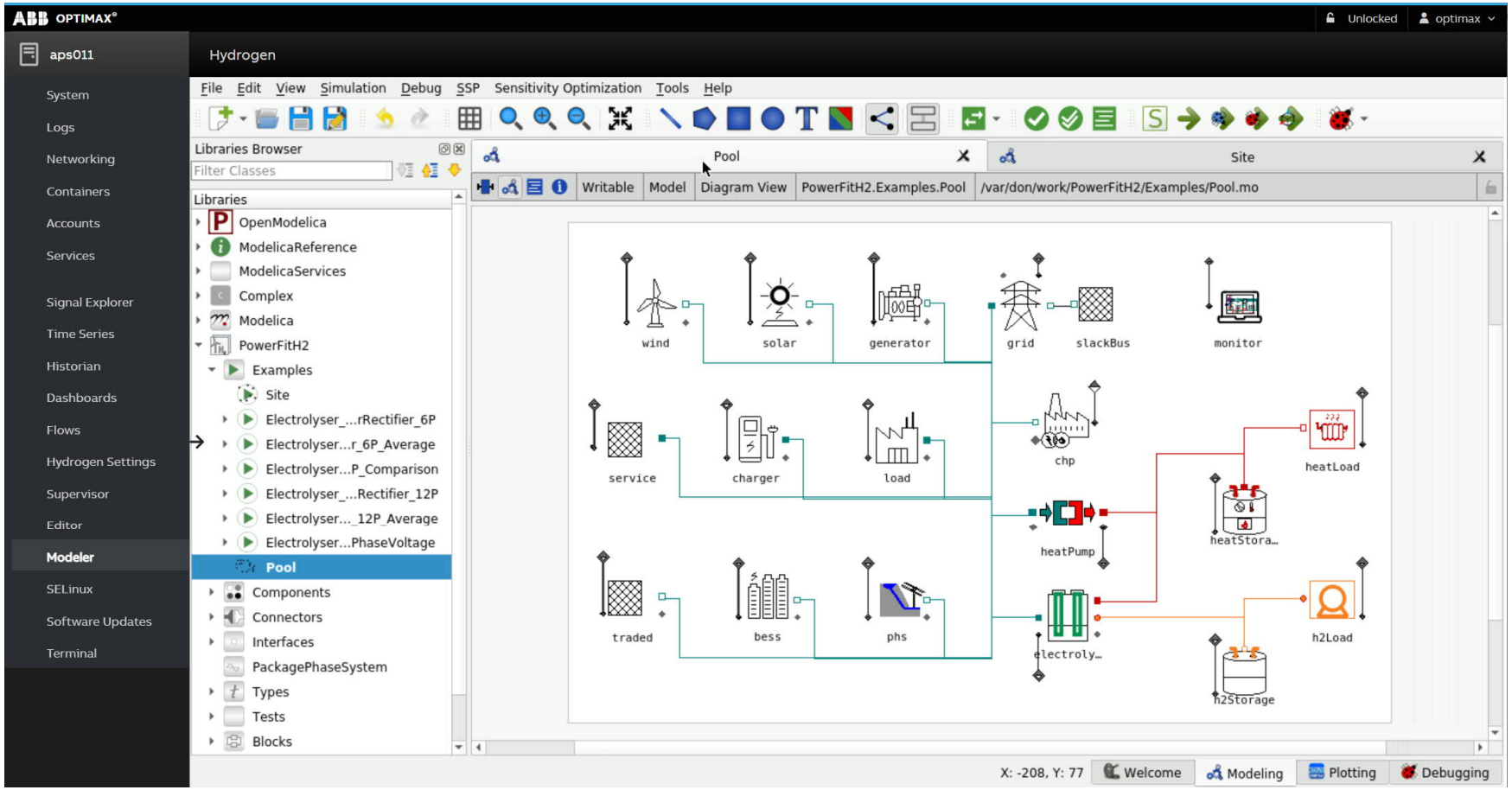
Wiring together hardware devices, APIs and online services

Wide range of nodes in the palette that can be deployed to its runtime

Browser-based editor that makes it easy to wire together flows

New: model engineering with OMEdit running as Docker with browser UI

Lowering the barrier for model-based optimization applications



Avoid separate engineering machine

Avoid cross compilation of FMU

Can preconfigure important settings for OPTIMAX:

- Reasonable diagnostic messages (backenddaedump, stateselection)
- C++ runtime with deterministic memory management
- FMI export with Clocks
- FMI with analytic Jacobian

Optional:

- Vectorized large-scale models
- Parallel multiple shooting (parallel FMU instances)

Lower barrier for model-based optimization applications

ABB Dynamic Optimization

Treat optimal control programs basing on simulation models

For dynamic system model and sample time points tk , t0 < t1 < … < tK

find control u (and/or initial states x(0)) that minimize criterion J

subject to mixed discrete/continuous model, initial conditions

and further constraints g

$$J = \sum_{k=0}^{K} f_0\left[k, \begin{pmatrix} x_d(k) \\ x_c(t_k) \end{pmatrix}, \begin{pmatrix} u_d(k) \\ u_c(t_k) \end{pmatrix}\right] \rightarrow \min_{\substack{x_d(0)\ u_d(0) \\ x_c(t_0)'\, u_c(t_0)}}$$

FMU ME

$$\begin{aligned} x_d(k+1) &= f_d[k, x_d(k), x_c(t_k), u_d(k)], & x_d(0) &= x_{d0}, & k &= 0,1,\dots,K \\ \frac{dx_c(t)}{dt} &= f_c[t, x_d(k(t)), x_c(t), u_c(t)], & x_c(t_0) &= x_{c0}, & t &\in [t_0, t_K] \\ y(k) &= h[k, x_d(k), x_c(t_k), u_d(k)], & & & k &= 0,1,\dots,K \end{aligned}$$

$$g[y(k(t)), u_d(k(t)), u_c(t)] \geq 0$$

OPTIMAX® Project References

Selected projects across energy industries

Kriegers Flak – 50 Hertz & Energinet DK

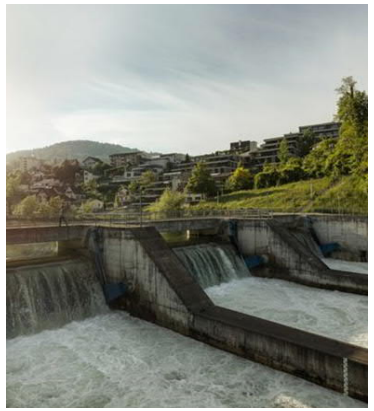
Optimal Power Flow interconnecting Danish and German electricity grid

- Interconnector control of Combined Grid Solution
- Wind farms: Baltic 1&2, Kriegers Flak A&B
- Realtime and predictive functions
- Power flow active and reactive
- First of its kind

EMSi – CKW AG

Combining decentralized power generating units and storages to a Virtual Power Plant

- Pooling decentralized assets like hydro power plants
- Participation in reserve energy markets (primary, secondary, tertiary)
- Full automation



C/sells – MVV AG

Integration of Power-2-Heat and solar

- Sector coupling with power-2-heat units directly coupled to pv park and grid
- Integration of thermal storages and exploiting the flexibilities
- Monitoring of all assets

Master Integrated Energy Systems


ABB