Scilab and Cloud Solutions for Hybrid Twin™

get it right®

www.esi-group.com

Hybrid Twin™ for system design & operation optimization

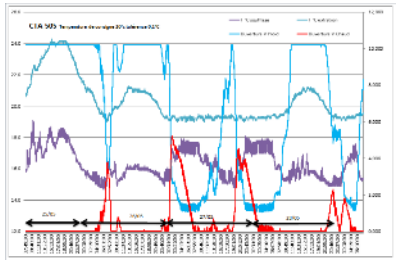
1. Model Reduction for optimal system design
2. Physics-based simulation
3. Simulation enriched by sensor data
4. Optimization powered by real-time simulation

Based on industrial energy-optimization use case at SANOFI

SANOFI using ESI Scilab Cloud ..
… to optimize energy costs through simulation

Problem

- Inefficient control of HVAC (Heating, Ventilation & Air Conditioning) leads to energy waste
- HVAC = 60 % of energy bill (example: 500k€/year/site)



Objectives

- Save 10M€+ /year in energy bills worldwide
- Energy efficiency at 100+ industrial sites

ESI Scilab Cloud application for:

- System design
- Operation optimization

A few words about Scilab & ESI Scilab Cloud

Scilab Highlights

Scilab® is competitive with Matlab®, but **open-source** and **free**

With Xcos, Scilab® offers a modular equivalent to Simulink® for control systems design & simulation

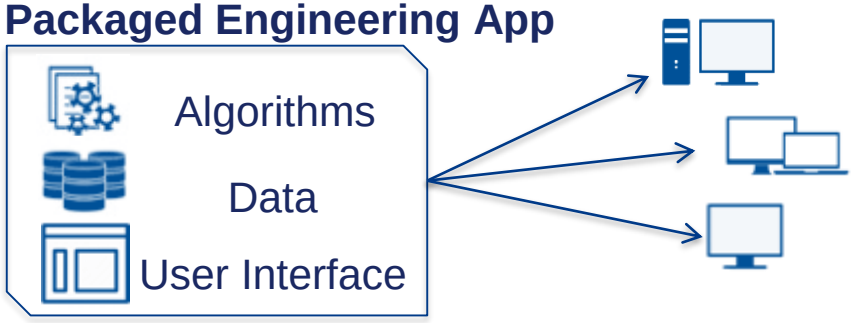
Scilab® has a 1M+ user community worldwide

ESI Scilab Cloud enables the secure cloud deployment of customers' scientific and engineering applications

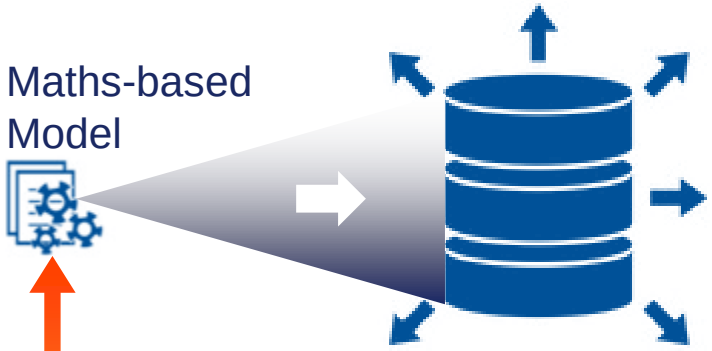
Developing & Deploying Hybrid Twin™ apps with Scilab

Application Development & Deployment

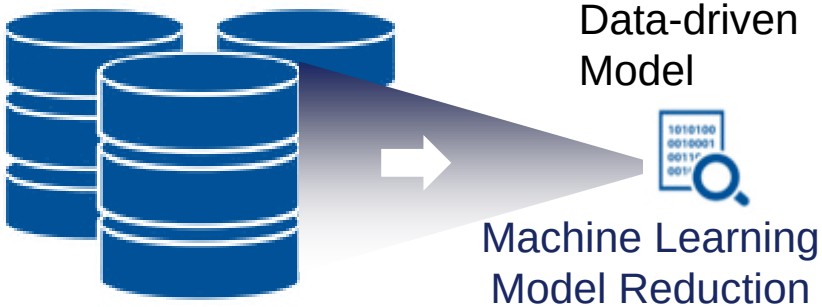
Packaged Engineering App



Modeling & Simulation

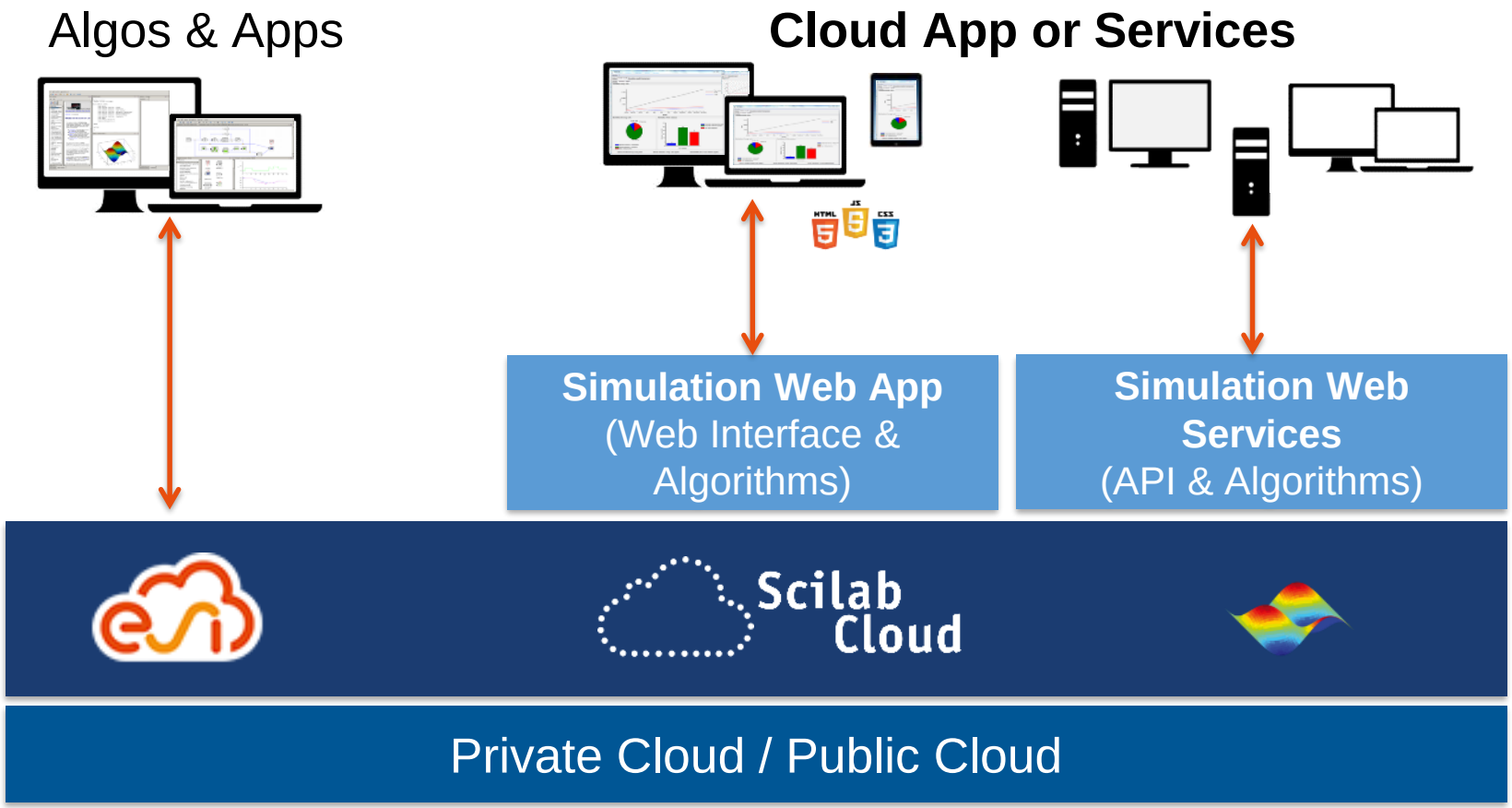


Scientific Data Analytics



Hybrid Twin™

Architecture



Taking Geometry into Account

Model Reduction for faster simulation

Optimizing the design of room temperature & humidity control

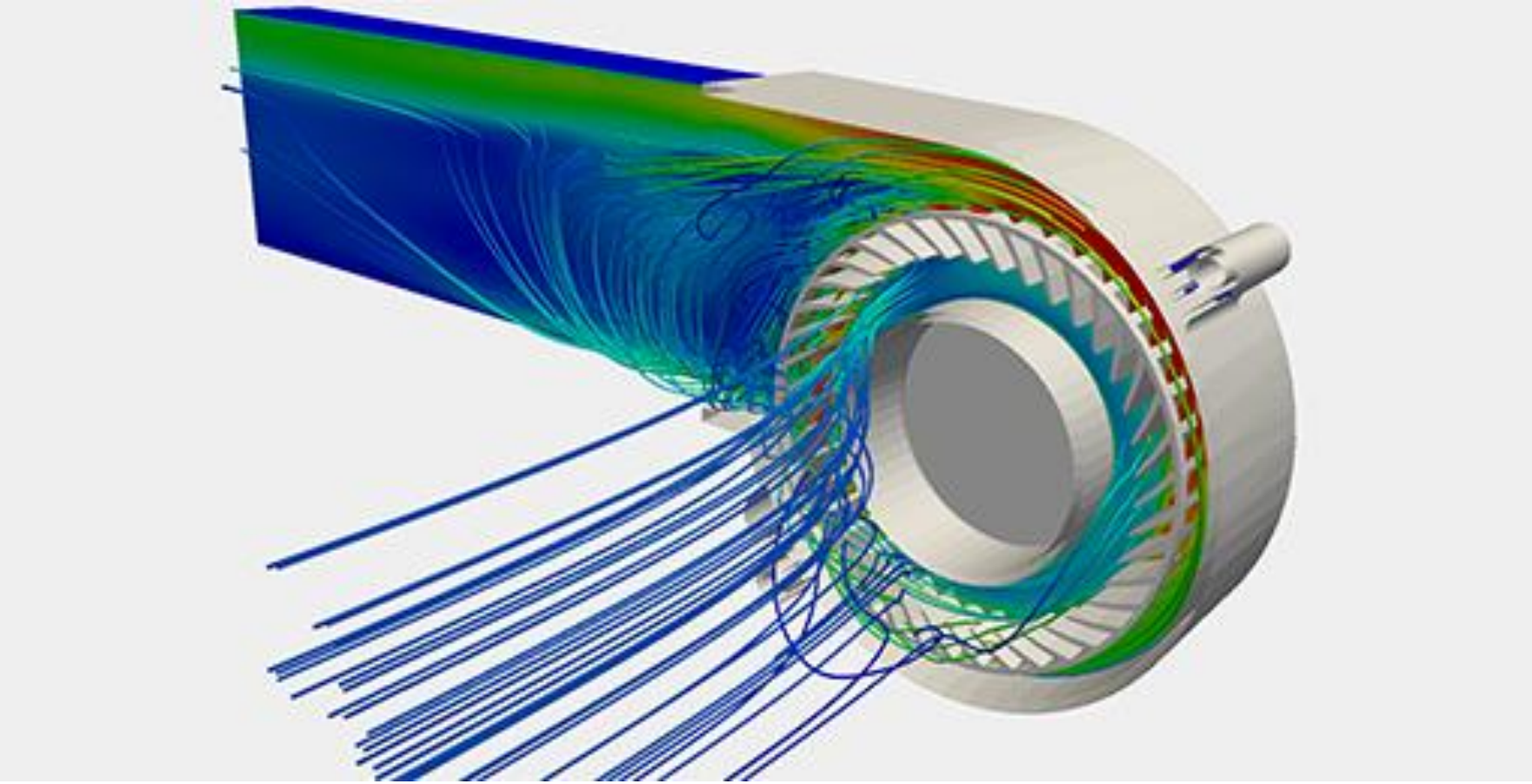
Objective : design of Heating, Ventilation, Air Conditioning (HVAC) systems to ensure low variation of temperature & humidity across room

Variable elements :
HVAC system type & power
Position & direction of ventilation ducts & exhausts

Issue :
Need for high-fidelity requires 3D models or equivalent but the computing power to simulate numerous configurations is very challenging!

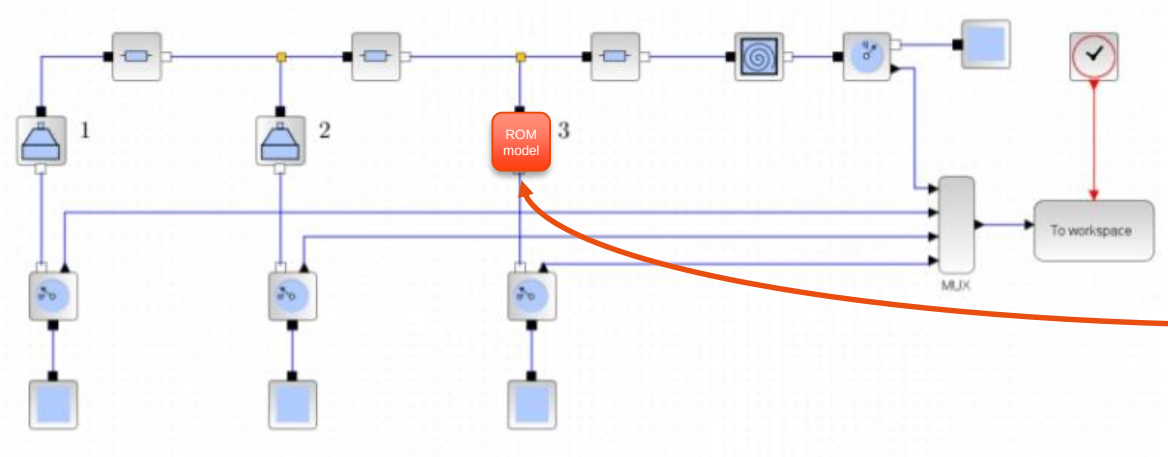
3D HVAC model

From full finite-element CFD models to Reduced-Order Models



Reduced-order model to allow design-space exploration

Physics-based System Model



Reduced Order Models

Exported as executable model

```
function ROModel()

    // Equations definition
    deff("[yd]=chem(t,y)",[
    "yd(1)=-0.04*y(1) + 1d4*y(2)*y(3);";
    "yd(3)= 3d7*y(2)*y(2);";
    "yd(2)= -yd(1) - yd(3);"])

    // finding points such that y1=1.e-4 or y3=1.e-2

    // Integration
    t    = [1.d-5:0.02:.4 0.41:.1:4 40 400 4000 40000 4d5 4d6 4d7 4d8 4d9
    rtol  = 1.d-4;atol=[1.d-6;1.d-10;1.d-6];
    y    = ode([1;0;0],0,t,rtol,atol,chem);

    // Visualisation

    my_handle = scf(100001);
    clf(my_handle,"reset");
```

Or called through Cloud REST API

https://scilab.cloud/rest/sanofi/optifan/v1_1/ROModel

HVAC control optimized by simulation

Physics-based simulation

HVAC control optimized by simulation

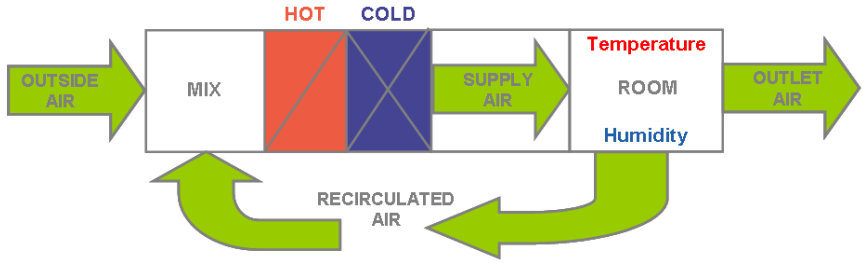
Sanofi's application (Opticlim)

Simulates the operation of HVAC systems based on

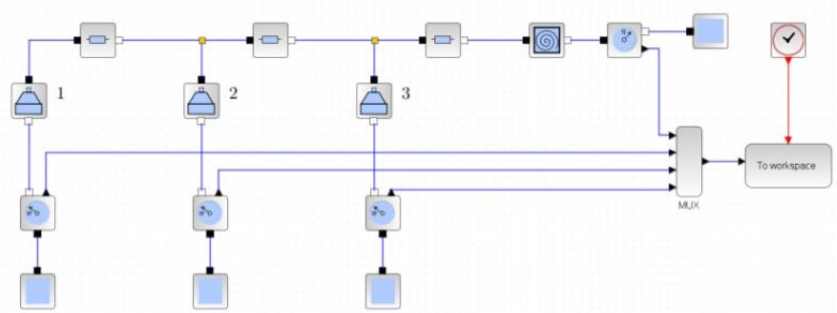
- Industrial site & HVAC **installation properties**
  HVAC set-up & industrial site properties (room size, operation hours,..)
- **Weather data** (Hourtly temperature & humidity)
- Actual **HVAC Settings** (Temperature, Humidity, Air flow)

Computes energy consumption (kWh) & costs (k€)

- Fan motors
- Heat generation
- Cold generation

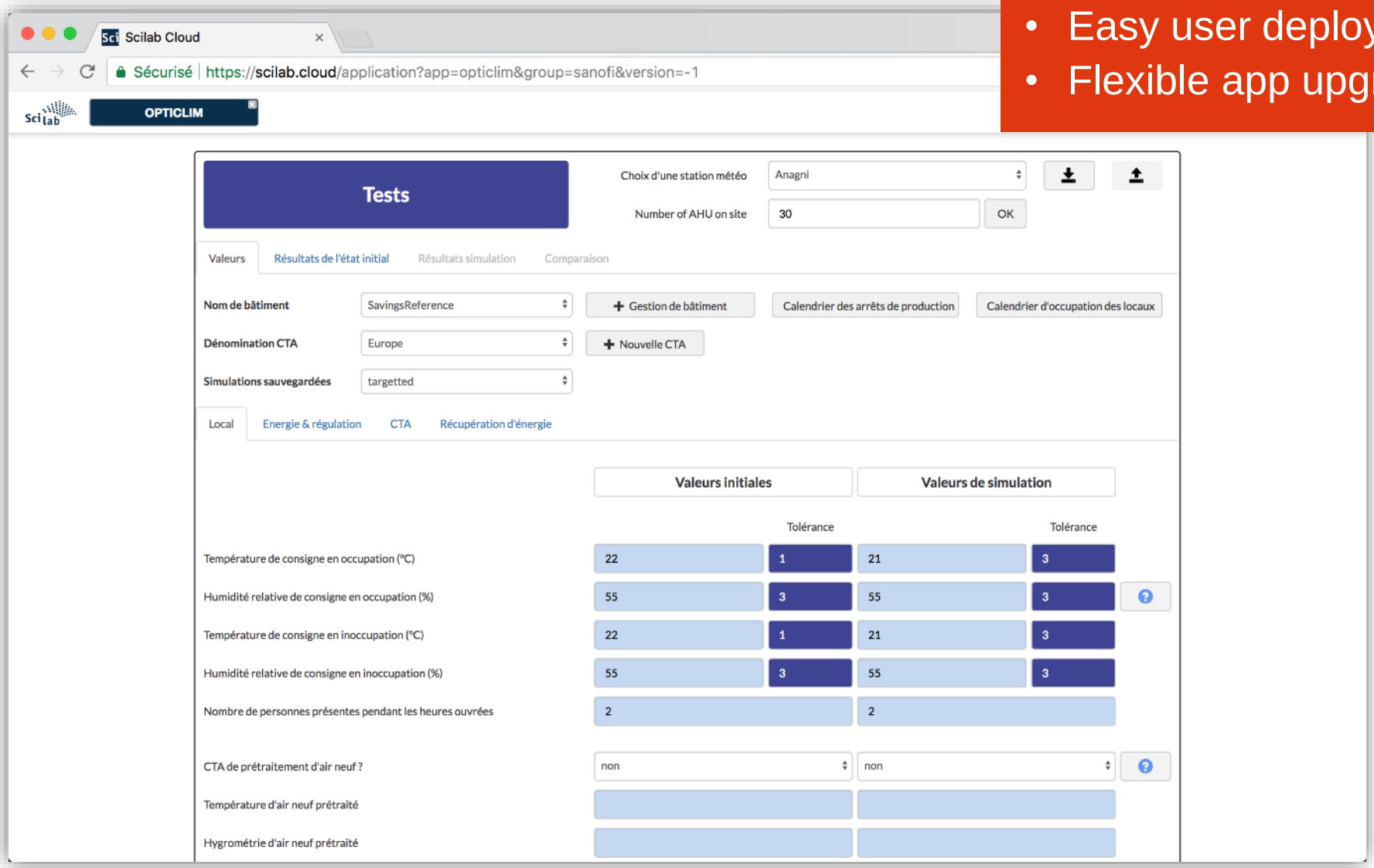


Physics-based Model



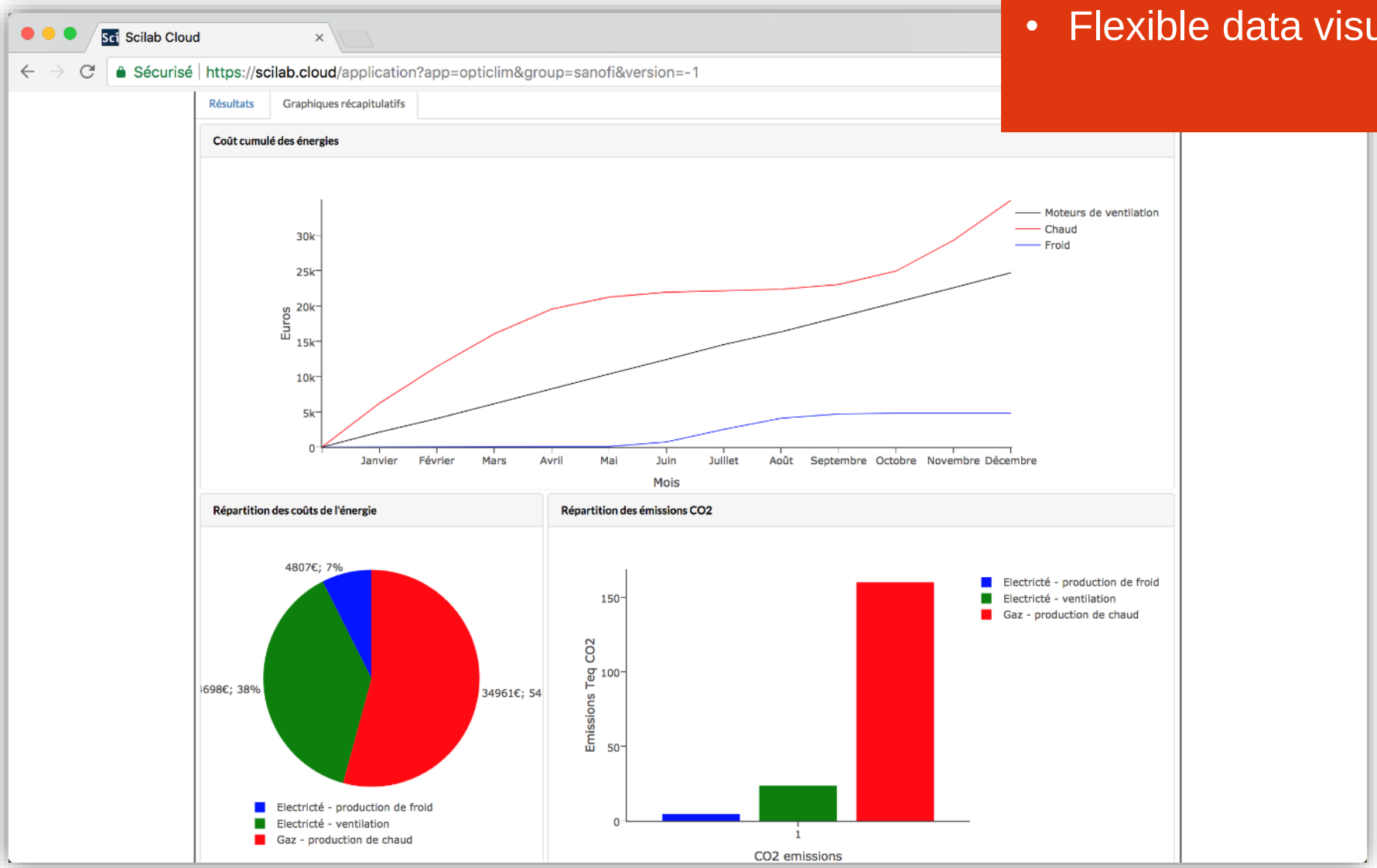
Opticlim powered by ESI Scilab Cloud

- Centralized data and models
- Easy user deployment
- Flexible app upgrade



Opticlim powered by ESI Scilab Cloud

- Flexible data visualization

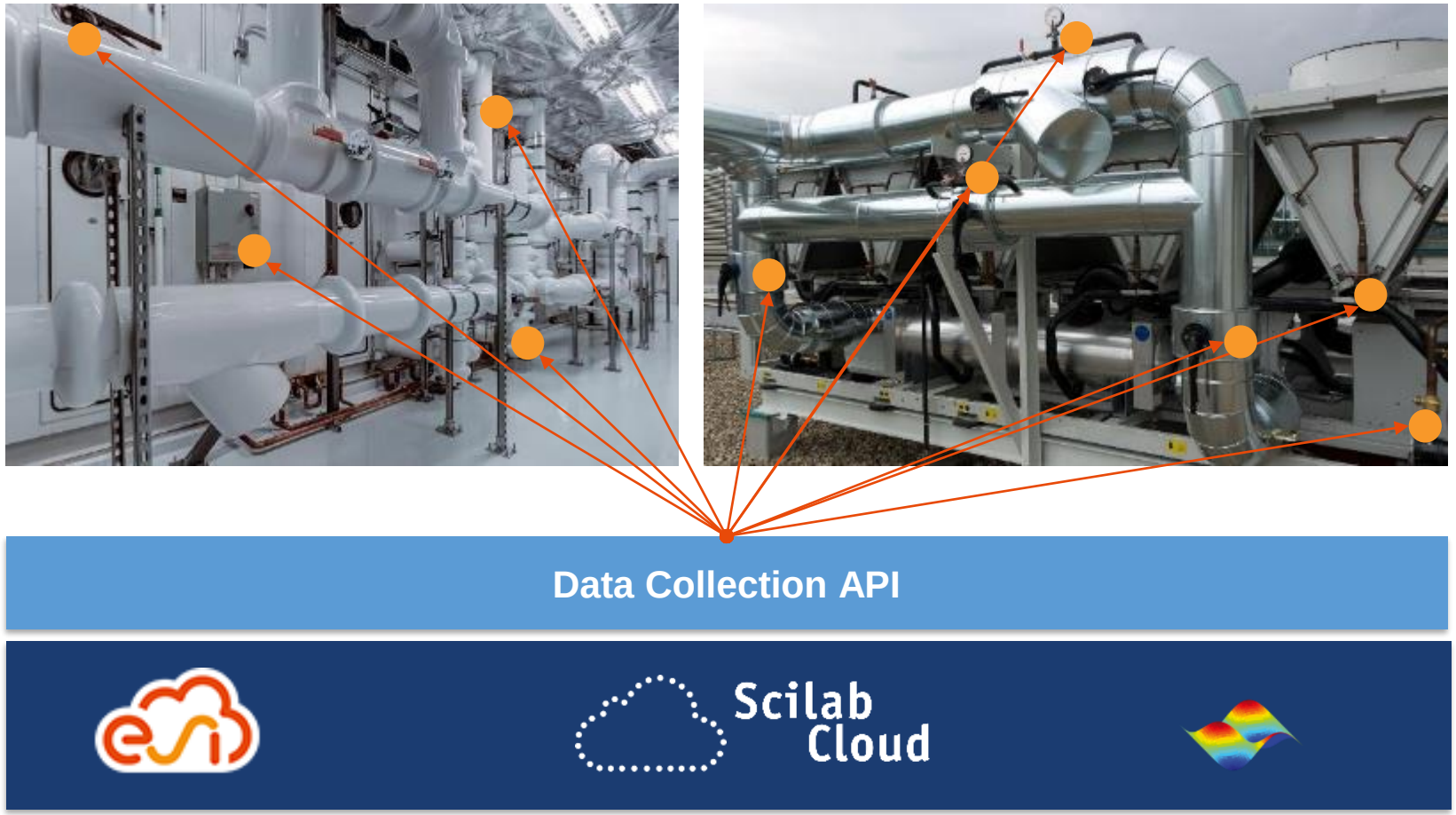


Simulation enriched by sensor data

Leverage insights from past data

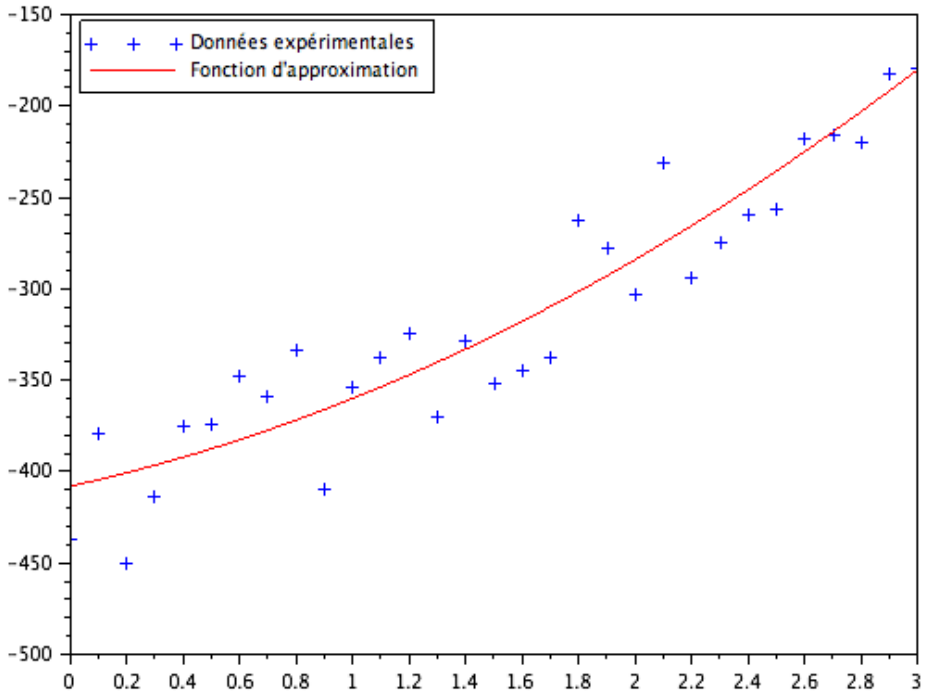
Sensors to collect operational HVAC system data

Deployment of network of low-cost wireless sensors

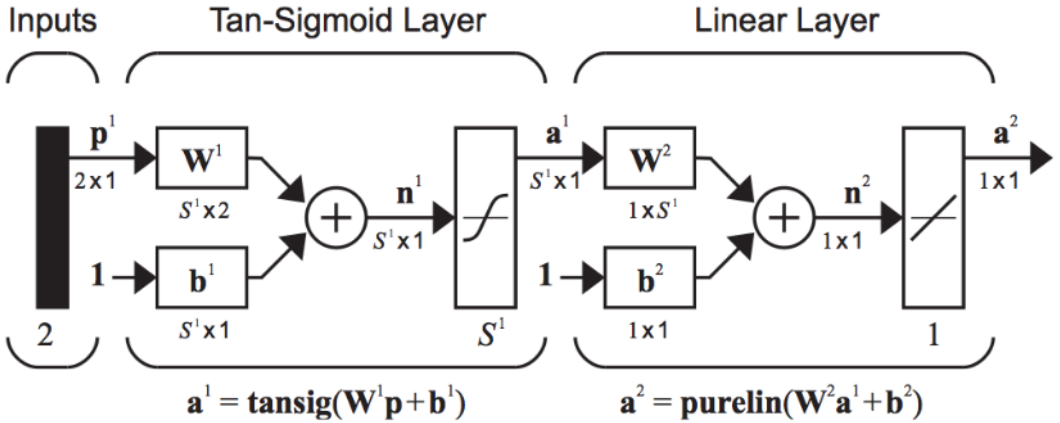


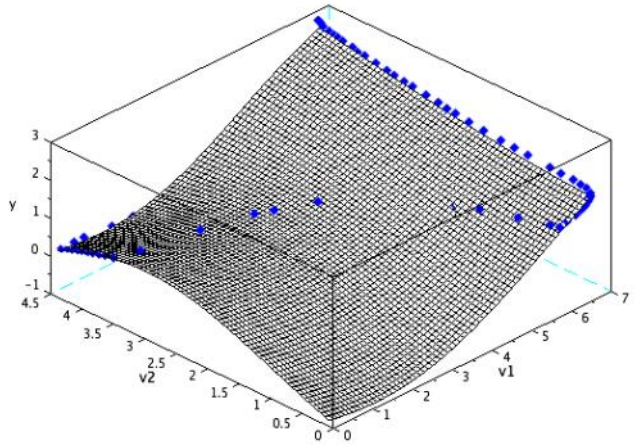
Learn from sensor data to build data-driven models

From data-fitting



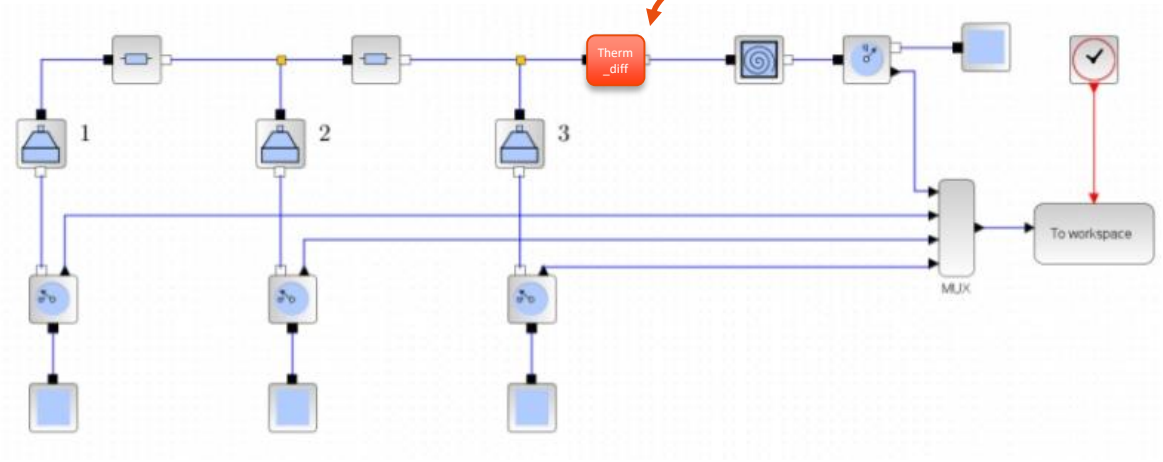
To machine learning





Data-driven models used to fine-tune physics-based model

Physics-based System Model



Data-driven Models

Exported as executable model

Export Decision Tree model

Download complete model in C++

```
string Model::SteelPlateManufacturing_Bumps::predict(void)
{
    string c_Bumps;

    if (is_null(c_Y_Perimeter)) {
        c_Bumps = "FALSE";
    }
    else if (c_Y_Perimeter <= 52.5) {
        if (is_null(c_Square_Index)) {
            c_Bumps = "FALSE";
        }
        else if (c_Square_Index <= 0.53065) {
            c_Bumps = "FALSE";
        }
        else if (c_Square_Index > 0.53065) {
            if (is_null(c_Length_of_Conveyer)) {
                c_Bumps = "FALSE";
            }
            else if (c_Length_of_Conveyer <= 1623.5) {
                c_Bumps = "FALSE";
            }
            else if (c_Length_of_Conveyer > 1623.5) {
                if (is_null(c_Steel_Plate_Thickness)) {
```

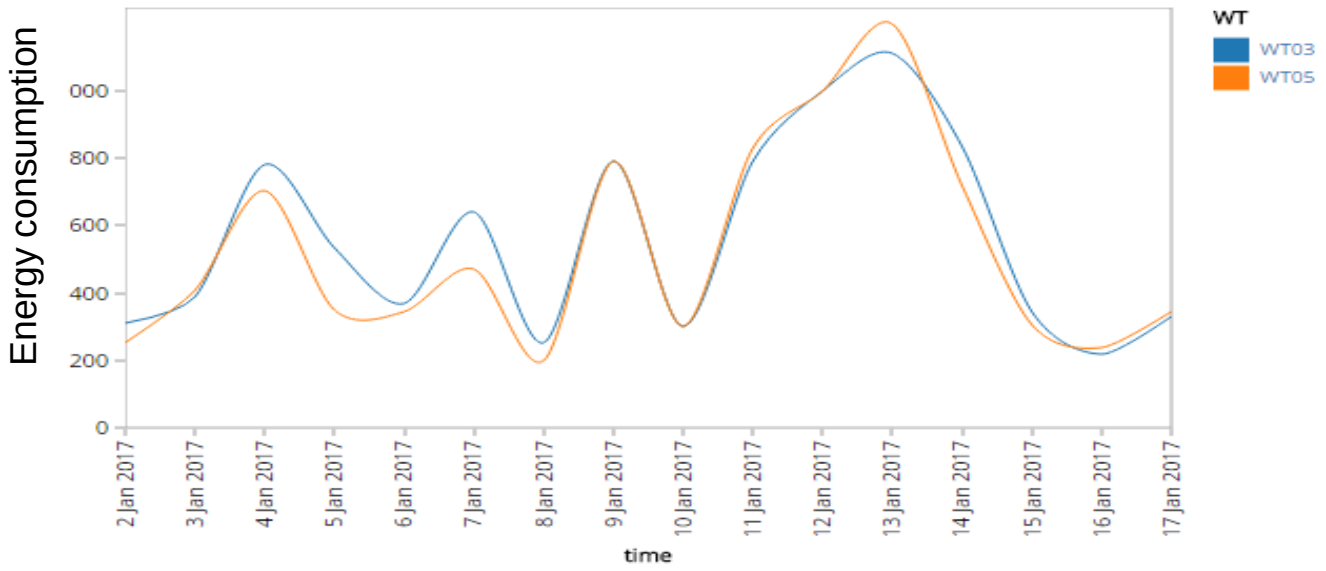
Or called through Cloud REST API

https://mineset.com/develop/api/models/15995/apply
https://scilab.cloud/rest/sanofi/opticlim/v2_4/therm_diff

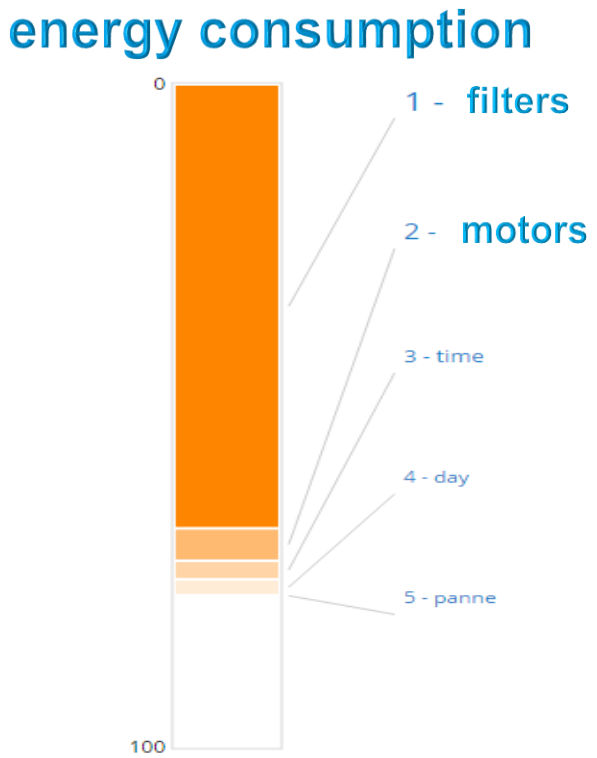
Performance Monitoring

Leverage ESI Mineset (industrial data analytics) to

1) Compare simulation with real operation data



2) Infer biggest predictors

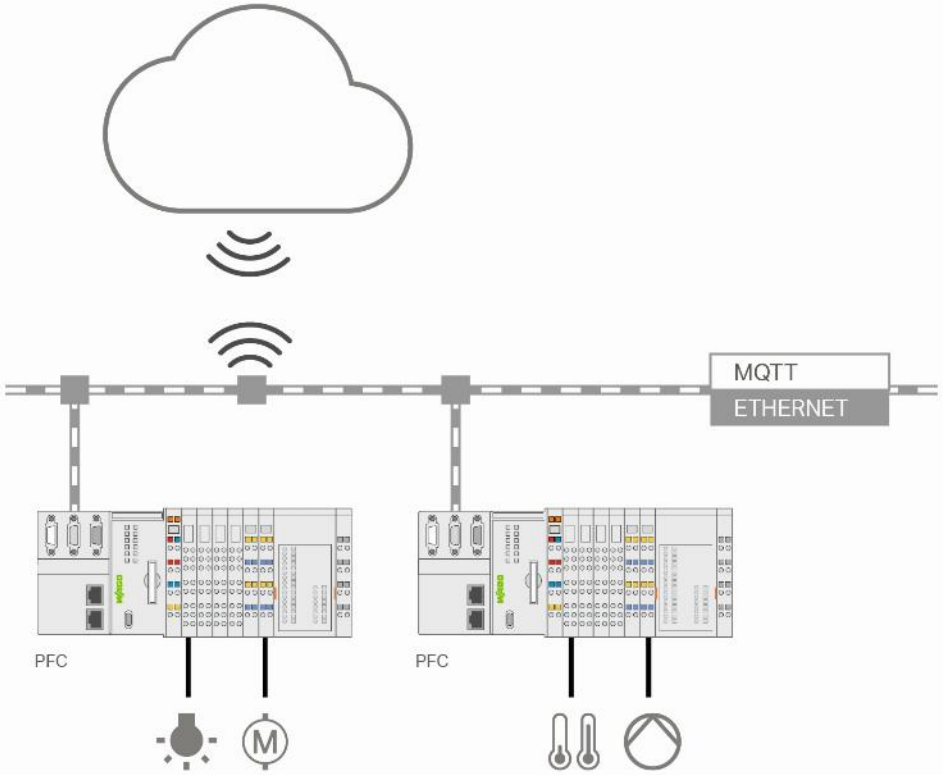


From offline to real-time optimization

Smarter control through real-time simulation

New trends in Programmable Logic Controllers (PLCs)

Connected PLCs for Cloud Computing



Courtesy WAGO

New trends in Programmable Logic Controllers

Linux & Windows for Edge Computing

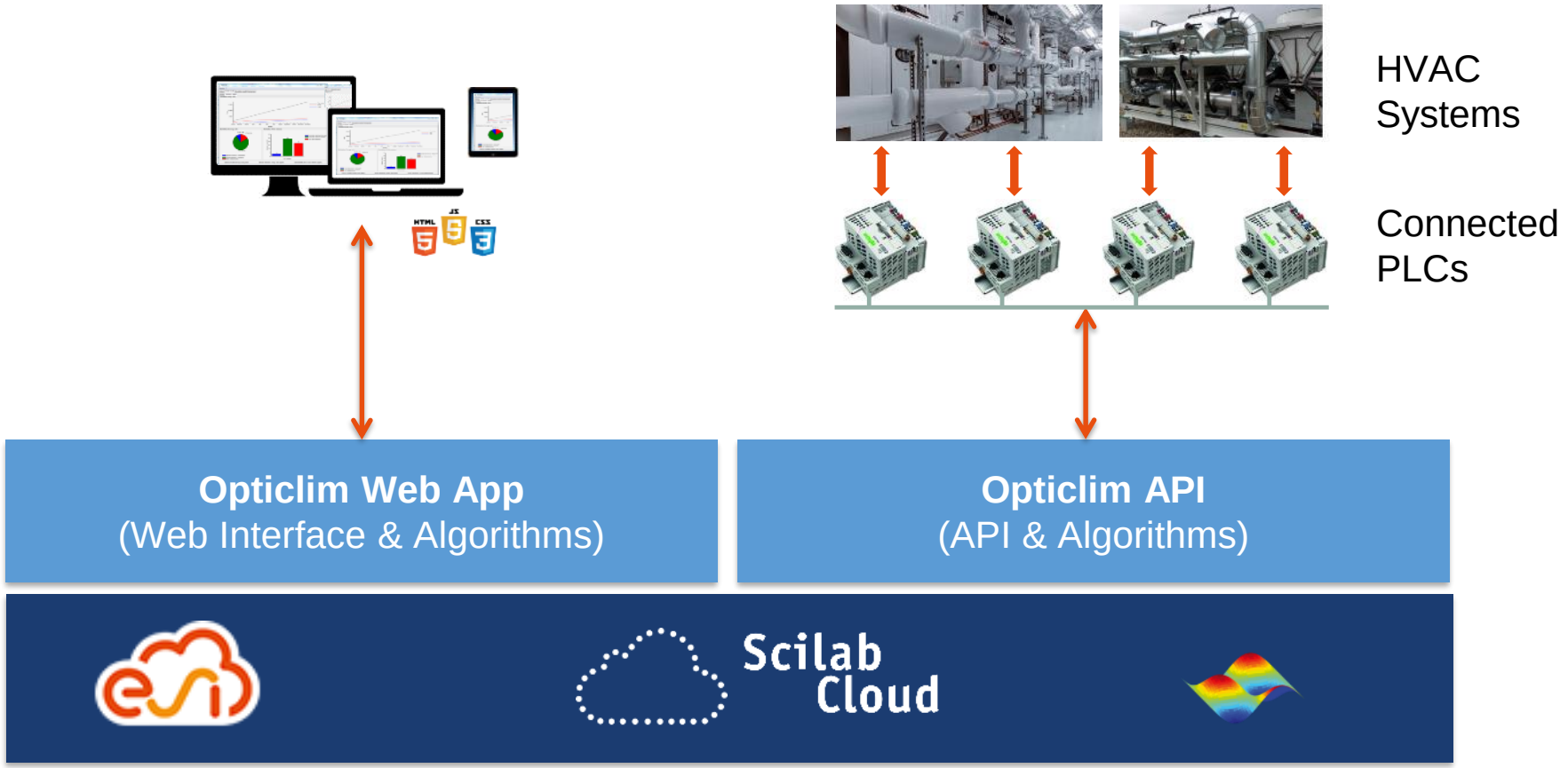
WAGO

Rockwell Automation

Allen-Bradley • Rockwell Software

From ESI Scilab Cloud application to connected PLCs

Industrial IoT applied to HVAC



Find out more

scilab.org/cloud