


Sci lab and Cloud Solutions
for
Hybrid Twin™

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

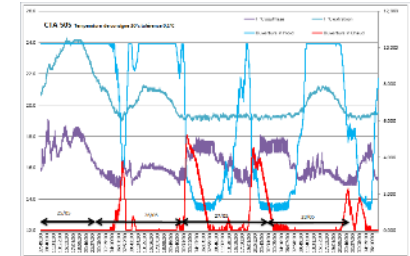
Based on industrial
energy-optimization
use case at
SANOFI

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

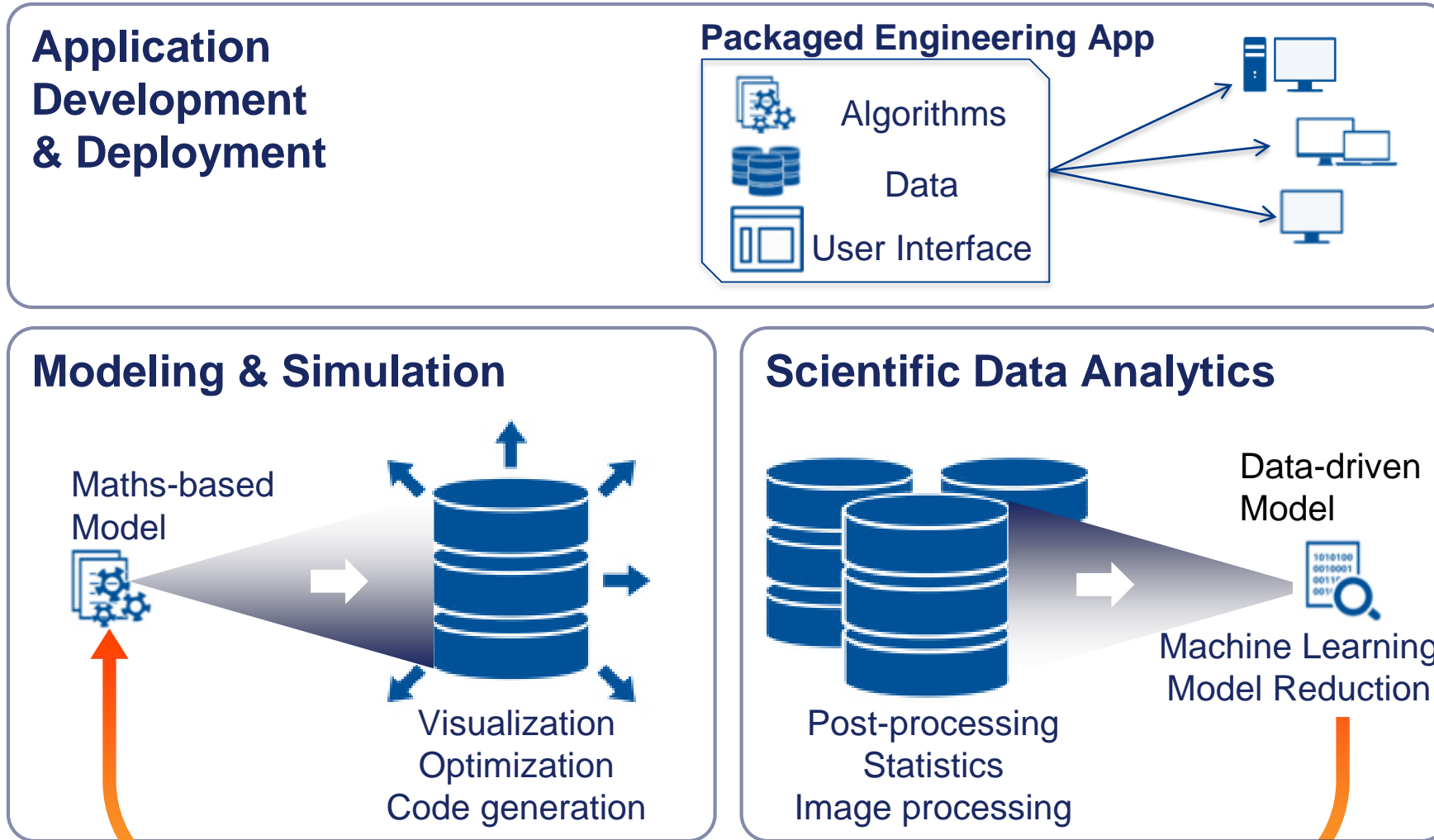
Scilab[®] is competitive with Matlab[®], but **open-source** and **free**

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

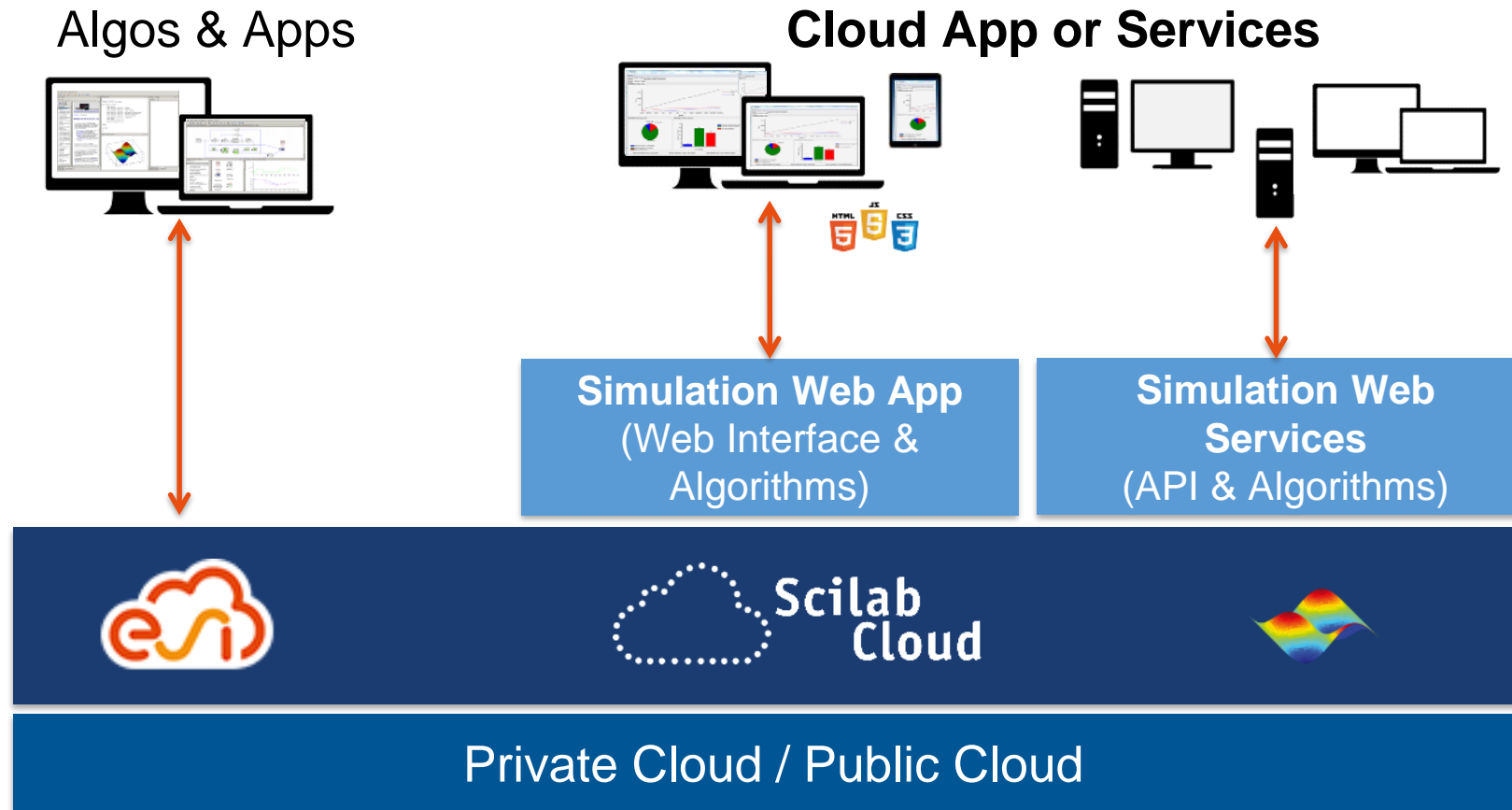
Scilab[®] has a 1M+ user community worldwide

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

Developing & Deploying **Hybrid Twin**TM apps with **Sci lab**



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

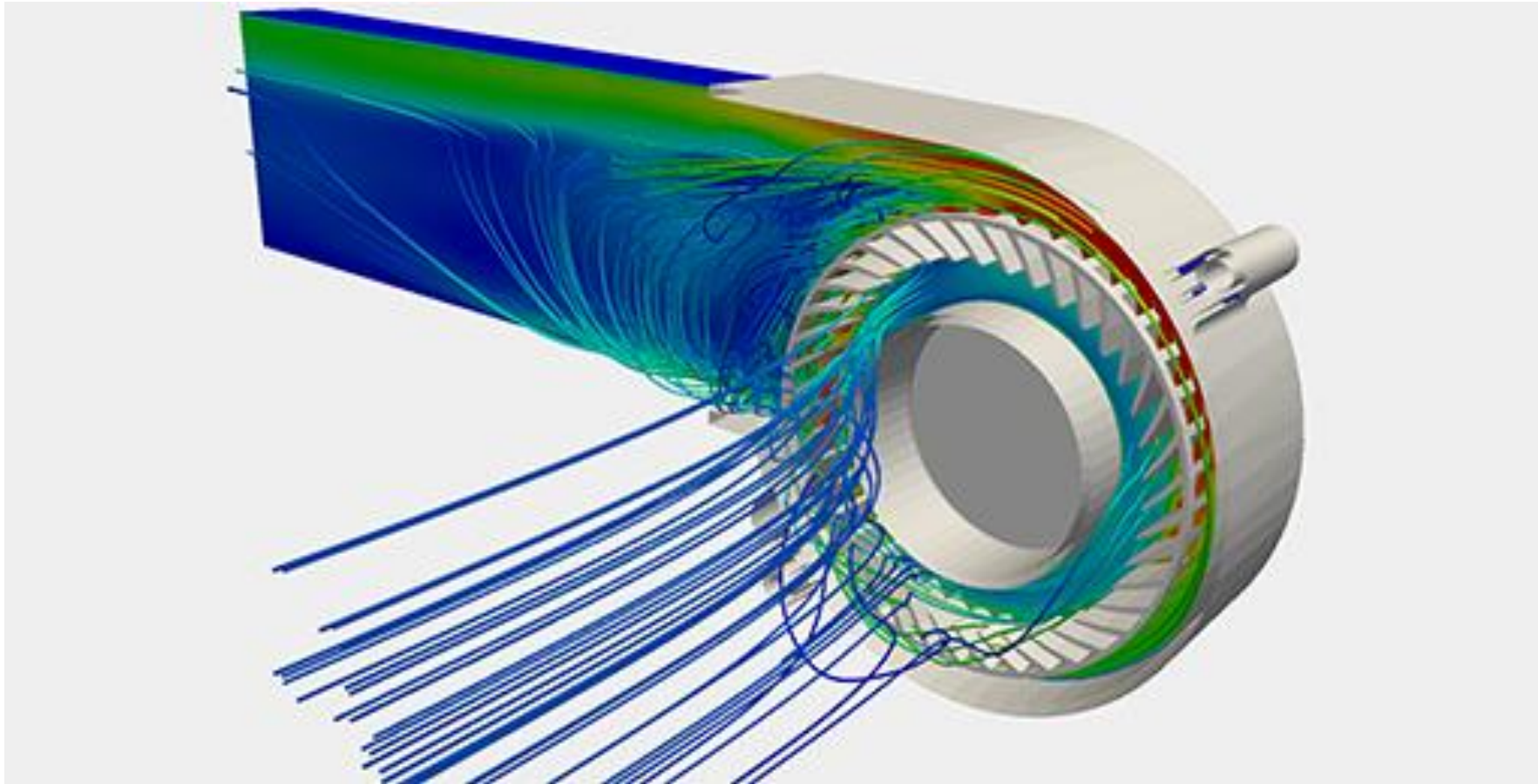
Issue :

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



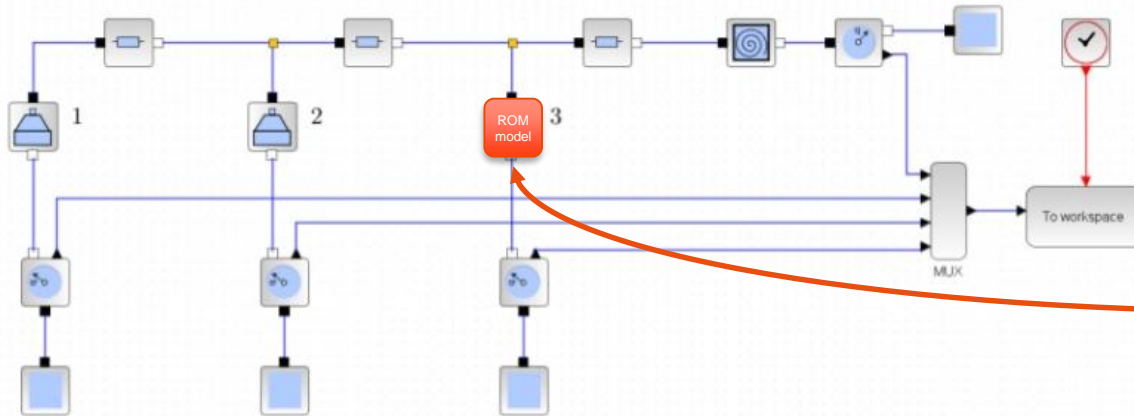
3D HVAC model

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  
... def("lyd]=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

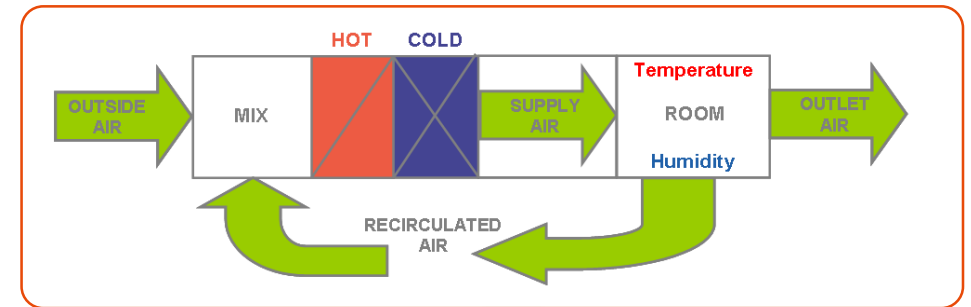
Sanofi's application (Opticlim)

Simulates the operation of HVAC systems based on

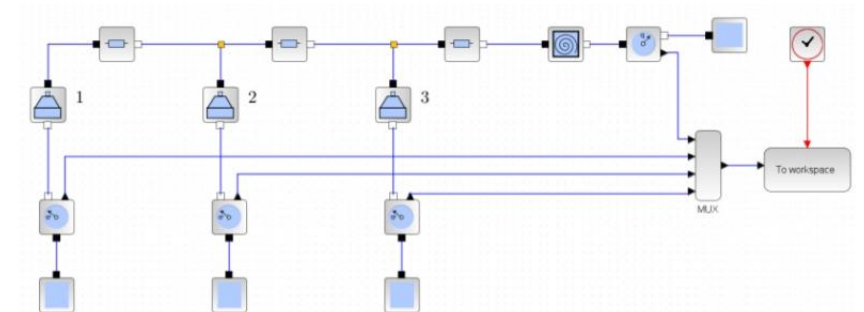
- Industrial site & HVAC **installation properties**
HVAC set-up & industrial site properties (room size, operation hours,...)
- **Weather data** (Hourly temperature & humidity)
- Actual **HVAC Settings** (Temperature, Humidity, Air flow)

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

The screenshot displays the Opticlim web application interface. At the top, the browser address bar shows the URL: <https://scilab.cloud/application?app=opticlim&group=sanofi&version=-1>. The application header includes the Scilab logo and the text "OPTICLIM".

The main interface is titled "Tests" and features a navigation menu with tabs: "Valeurs", "Résultats de l'état initial", "Résultats simulation", and "Comparaison". The "Valeurs" tab is active.

Key configuration elements include:

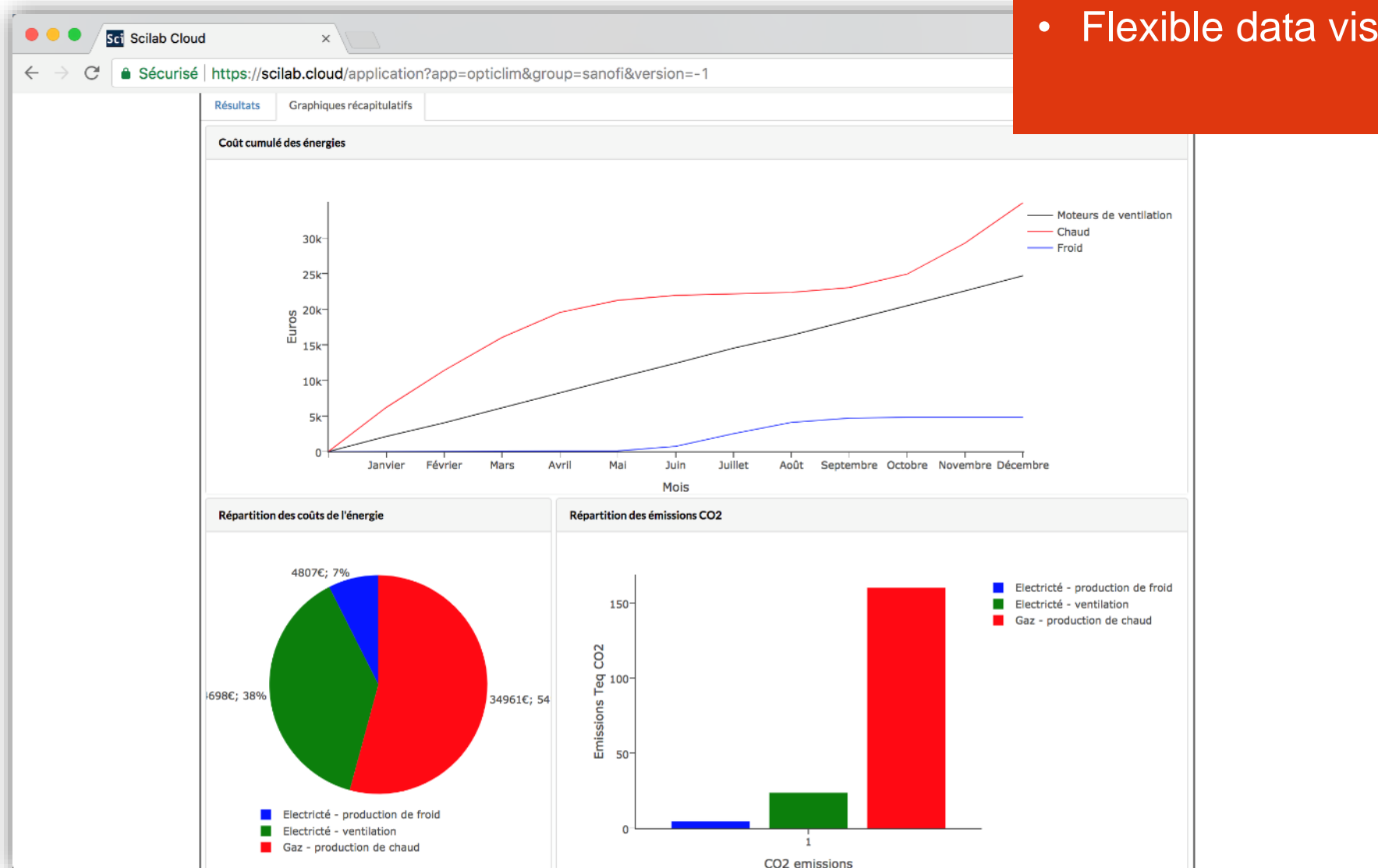
- Choix d'une station météo:** A dropdown menu set to "Anagni" with download and upload icons.
- Number of AHU on site:** A text input field containing "30" and an "OK" button.
- Nom de bâtiment:** A dropdown menu set to "SavingsReference" with a "+ Gestion de bâtiment" button.
- Dénomination CTA:** A dropdown menu set to "Europe" with a "+ Nouvelle CTA" button.
- Simulations sauvegardées:** A dropdown menu set to "targetted".
- Local:** A sub-menu with tabs for "Energie & régulation", "CTA", and "Récupération d'énergie".

The main content area is divided into two columns: "Valeurs initiales" and "Valeurs de simulation". Each column has a "Tolérance" label above it. The parameters and their values are as follows:

Paramètre	Valeurs initiales	Tolérance	Valeurs de simulation	Tolérance
Température de consigne en occupation (°C)	22	1	21	3
Humidité relative de consigne en occupation (%)	55	3	55	3
Température de consigne en inoccupation (°C)	22	1	21	3
Humidité relative de consigne en inoccupation (%)	55	3	55	3
Nombre de personnes présentes pendant les heures ouvrées	2		2	
CTA de prétraitement d'air neuf?	non		non	
Température d'air neuf prétraité				
Hygrométrie d'air neuf prétraité				

Opticlim powered by ESI Scilab Cloud

- Flexible data visualization

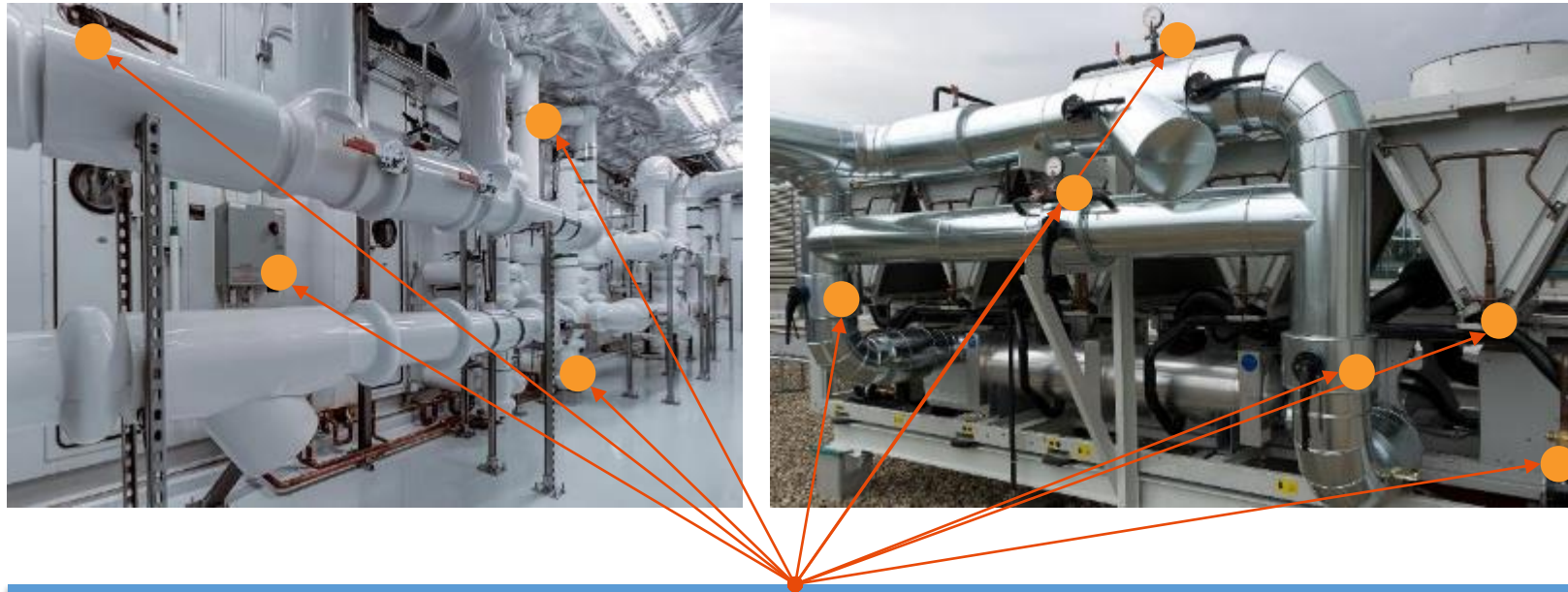


Simulation enriched by sensor data

Leverage insights from past data

Sensors to collect operational HVAC system data

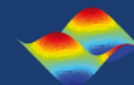
Deployment of network of low-cost wireless sensors



Data Collection API

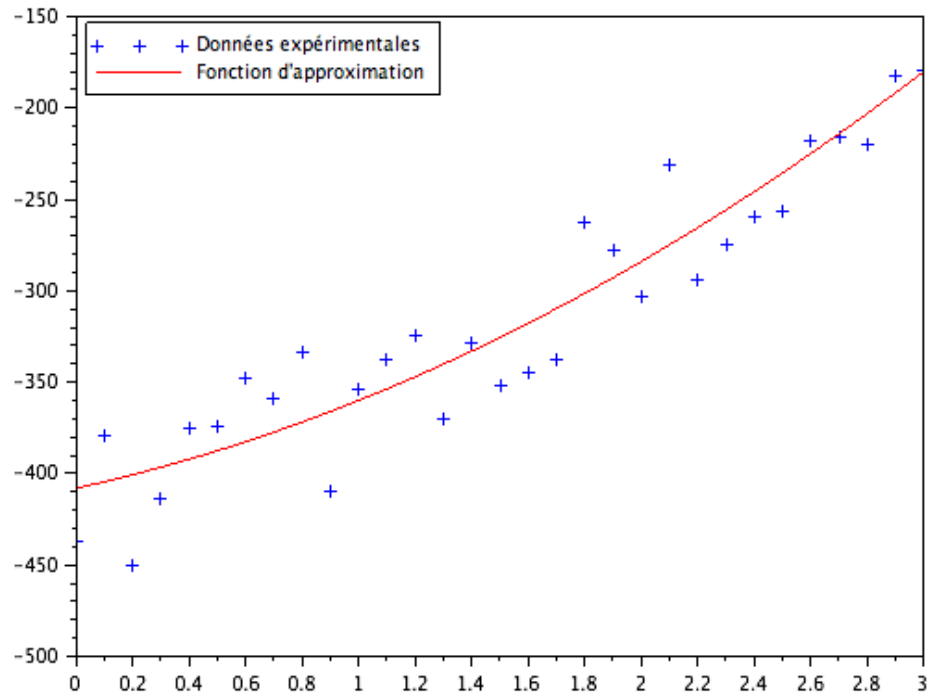


Scilab
Cloud

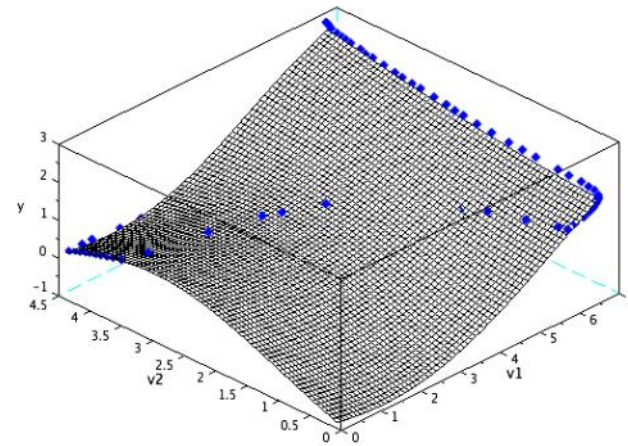
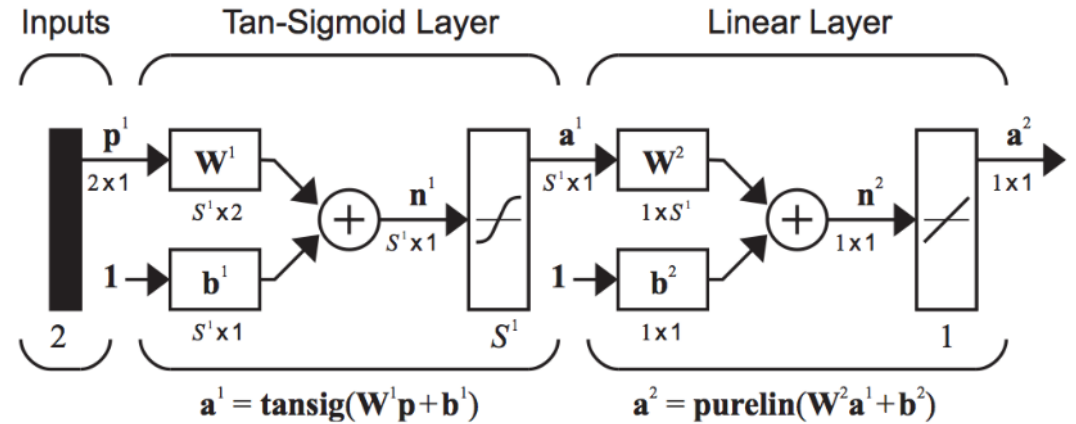


Learn from sensor data to build data-driven models

From data-fitting

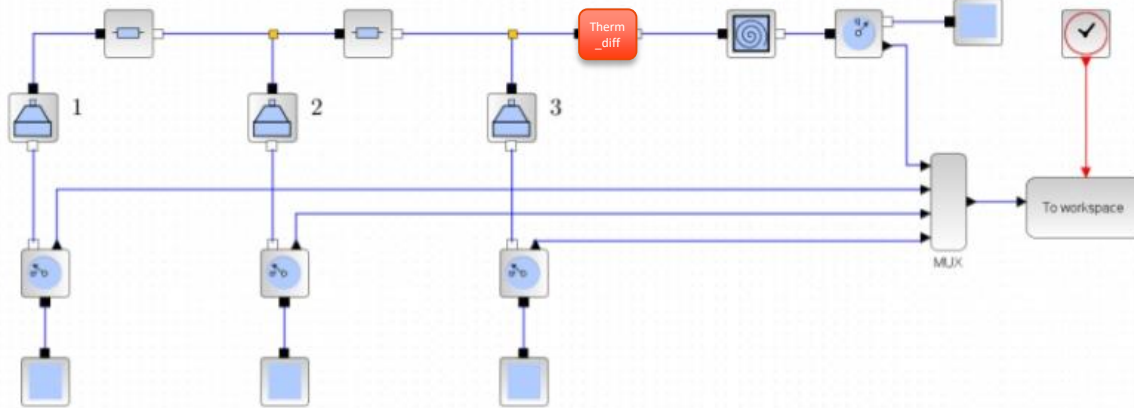


To machine learning



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

```
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)) {
                    c_Bumps = "TRUE";
                }
            }
        }
    }
}
```

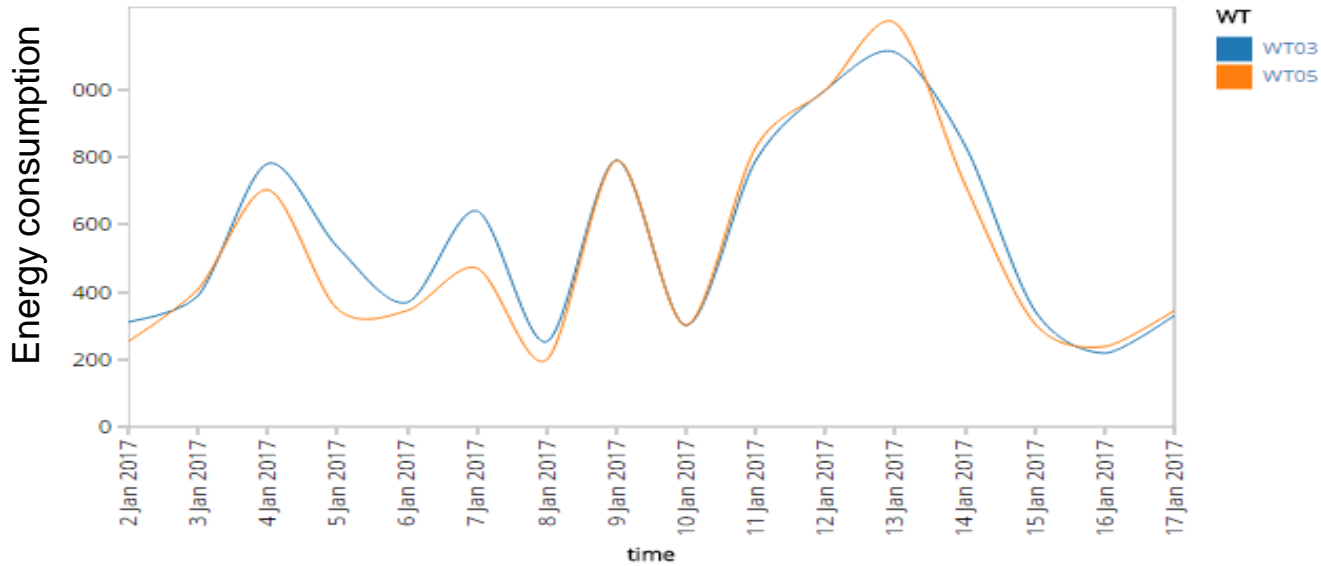
Or called through Cloud REST API

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

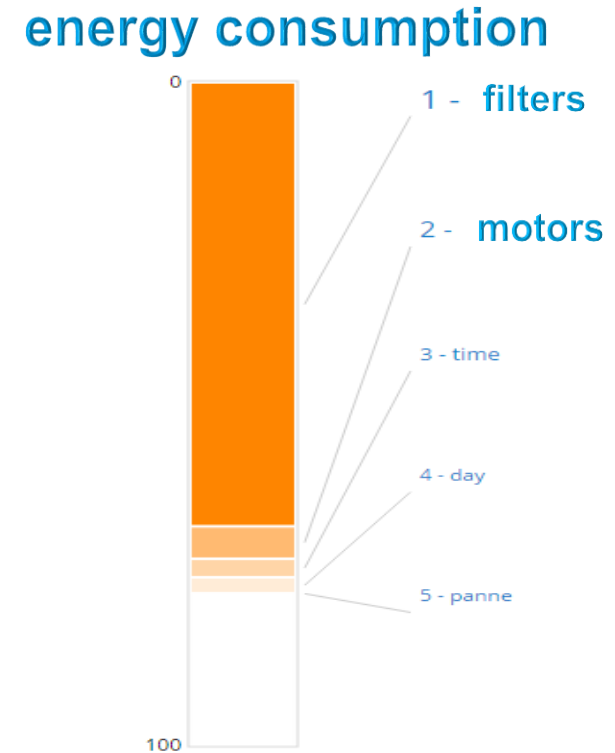
Performance Monitoring

Leverage ESI Mineset (industrial data analytics) to

1) Compare simulation with real operation data



2) Infer biggest predictors

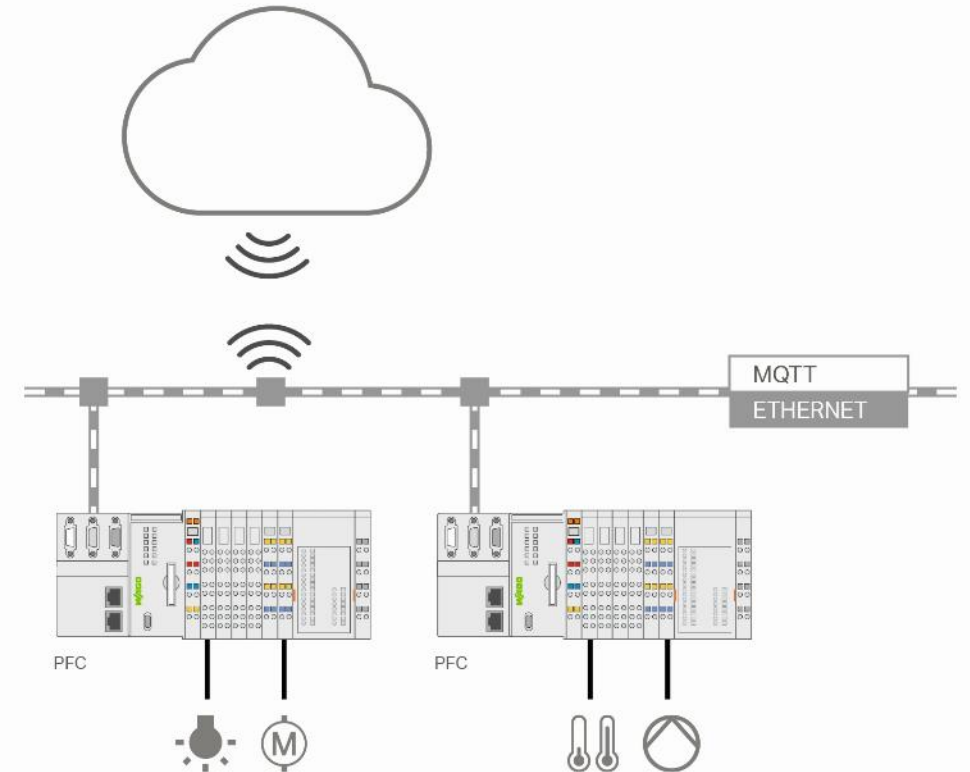


From offline to real-time optimization

Smarter control through real-time simulation

New trends in Programmable Logic Controllers (PLCs)

Connected PLCs for Cloud Computing



New trends in Programmable Logic Controllers

Linux & Windows for Edge Computing



WAGO



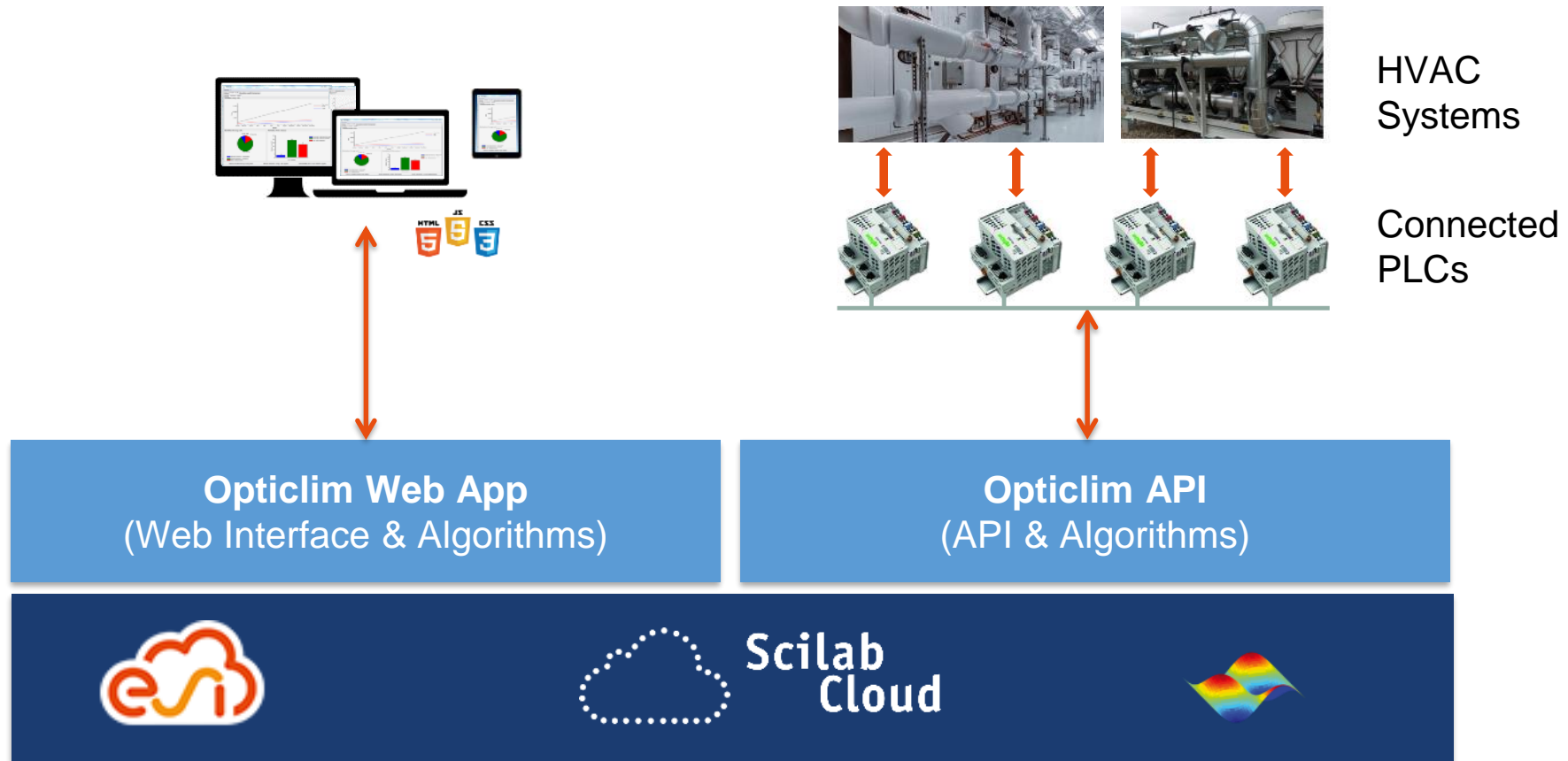
**Rockwell
Automation**



Allen-Bradley • Rockwell Software

From ESI Scilab Cloud application to connected PLCs

Industrial IoT applied to HVAC





Find out more

scilab.org/cloud