



BIM to emulate BIPV Digital Twin

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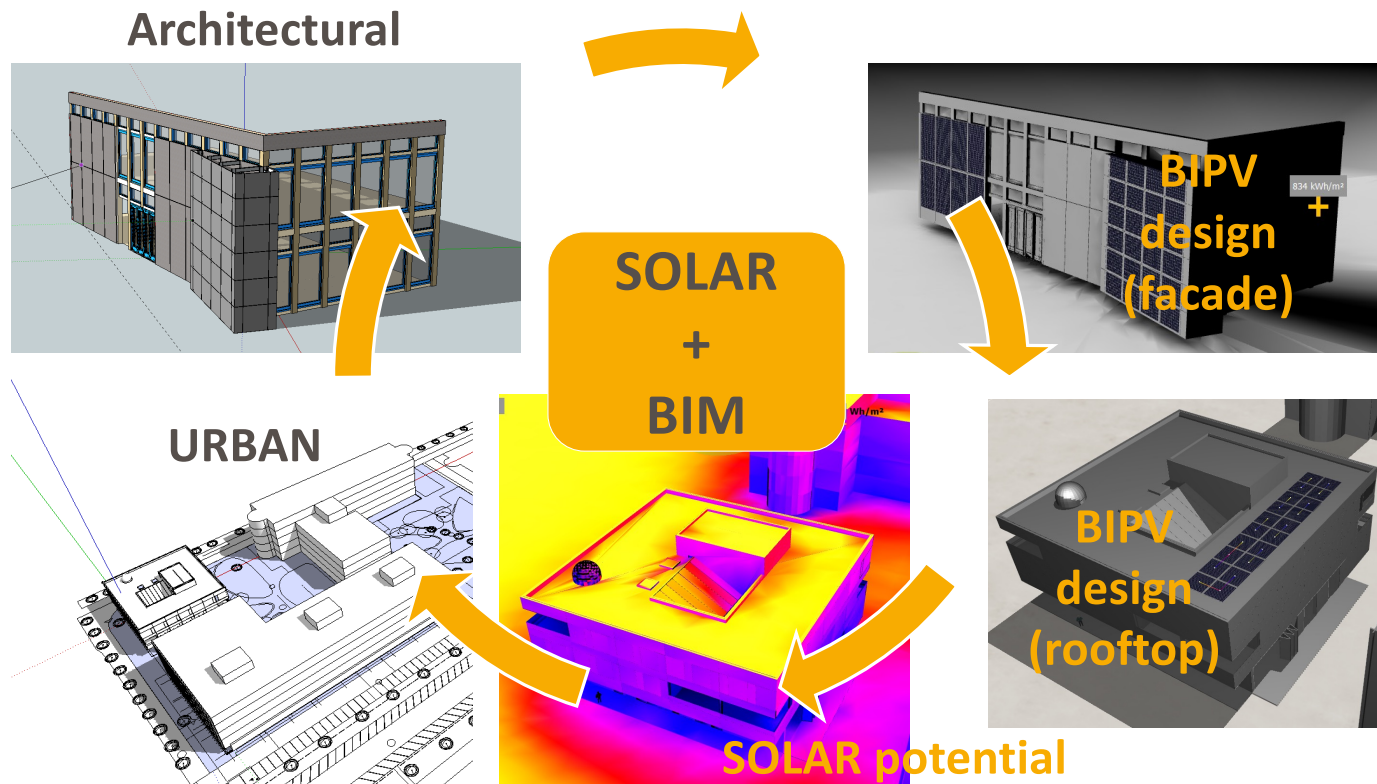
Scuola universitaria professionale
della Svizzera italiana

SUPSI

tecnal:a



AMBITION: from architectural design to BIPV valuation

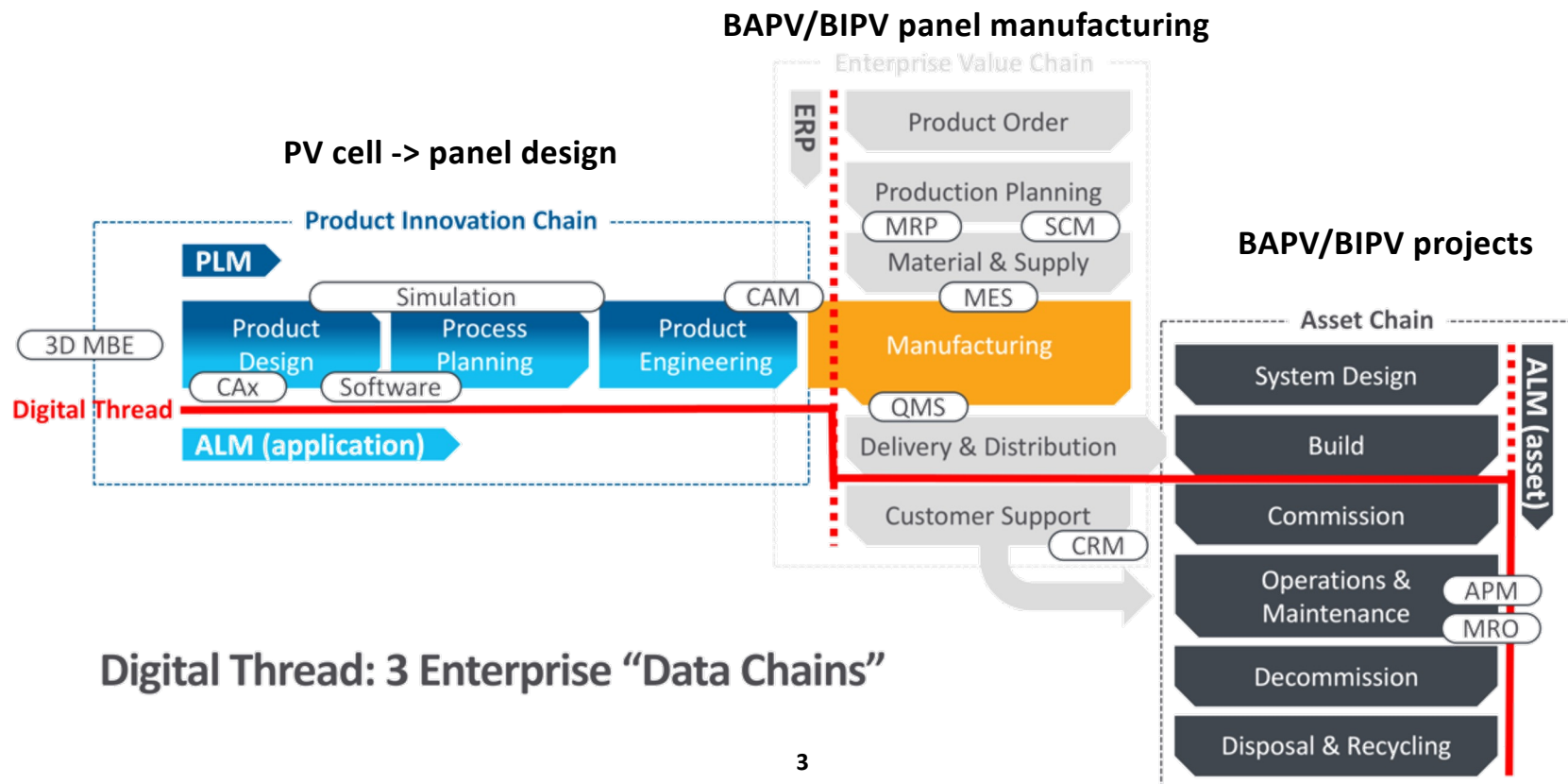


DIGITAL SKILLS to
BOOST solar
integration in the
AEC workflows

1. Support concept design
2. Enrich technical design
3. Connect manufacturing
4. Organize installation
5. Anticipate O&M
6. Reduce costs / mitigate risks

The evolving Digital Thread towards a holistic Digital Twin

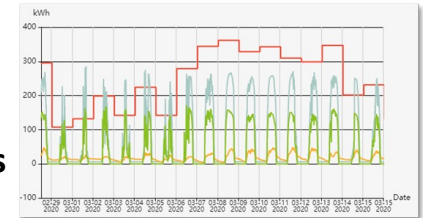
Gain deeper insight into current and past performance (root cause)



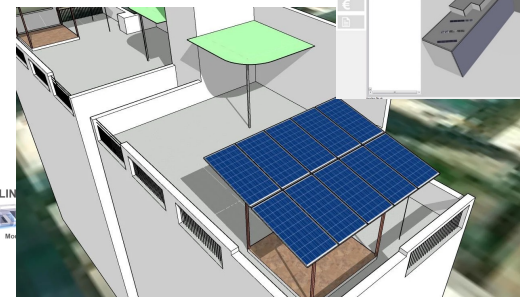
DIGITAL THREAD: linked data management

The Digital Thread is the Solution to Overcome Information Challenges

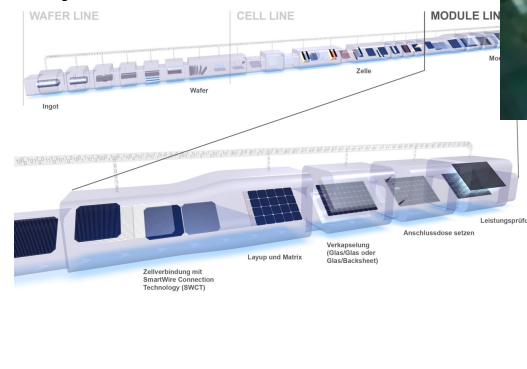
Digital Twins



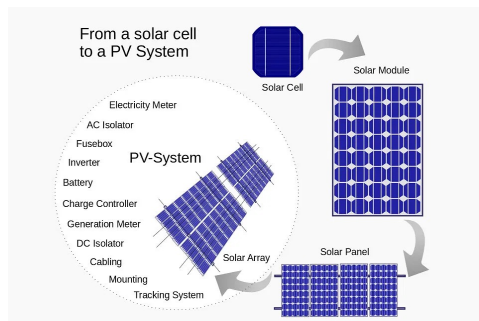
BIM



CAD-PLM-PPC



Word, PDF, Photoshop
SketchUp ...



interoperability

DIGITAL THREAD to DIGITAL TWIN

***Representation of a product or system (PV integrated system) mimicking its behavior...
...enabled by an «interoperable» Digital Thread***

Costs Calculation

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Cancel Proceed

Investment costs details

Type	Items	Costs (€)
PV modules system	Riason - Innovation 1.4	105.48
PV modules system	Riason - eFlex 1.6m FF60 1	175.80
PV modules system	Riason - eFlex 1.6m FF60 2	175.80
PV modules system	SOLITEK - Bifacial Ref 1	703.20
PV modules system	Apollon Solar - Bifacial Ref 1	351.60
PV modules system	Apollon Solar - Bifacial Ref 2	351.60
PV modules system	Riason - Innovation 1.5	140.64
PV modules system	Riason - Innovation 1.6	140.64
Inverter	ABB - UNO-DIM-2.0-TL-PLUS	780.85
Inverter	ABB - UNO-DIM-2.0-TL-PLUS	780.85
Inverter	ABB - UNO-DIM-2.0-TL-PLUS	780.85
Inverter	ABB - UNO-DIM-2.0-TL-PLUS	780.85
Inverter	ABB - UNO-DIM-1.2-TL-PLUS	337.76
Inverter	ABB - UNO-DIM-1.2-TL-PLUS	337.76

Investment costs (CC): 6202.46 €

Installation costs (IC): 620.25 €

Decommission costs (DC): 620.25 €

Capital costs (Cap): 341.14 €

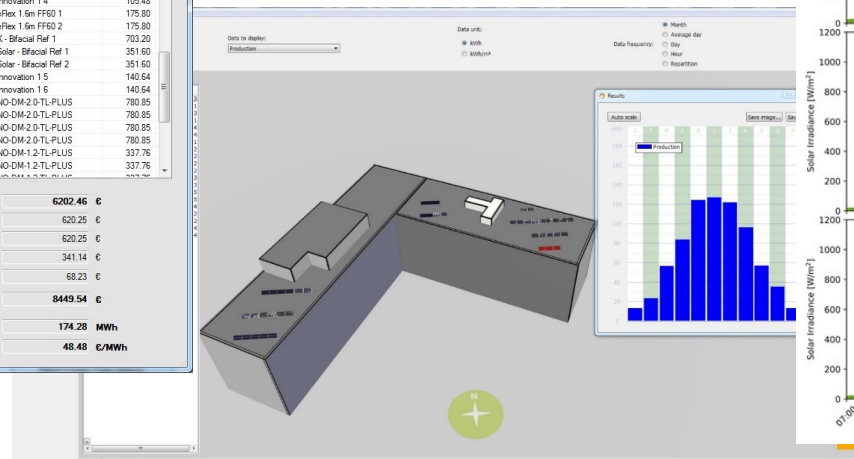
Maintenance costs (M): 68.23 €

TOTAL costs: 8449.54 €

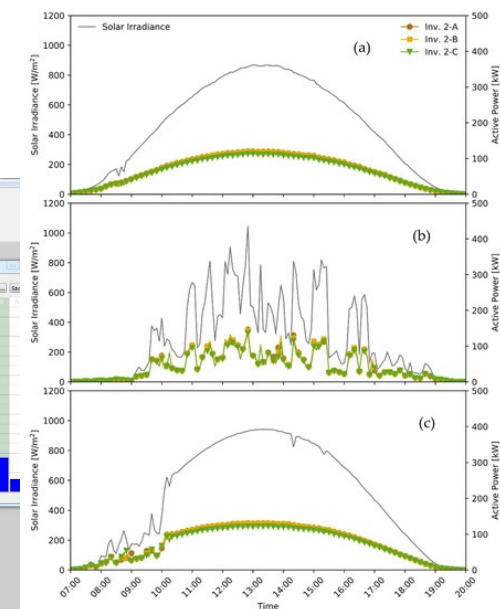
Production: 174.28 MWh

LCOE: 48.48 €/MWh

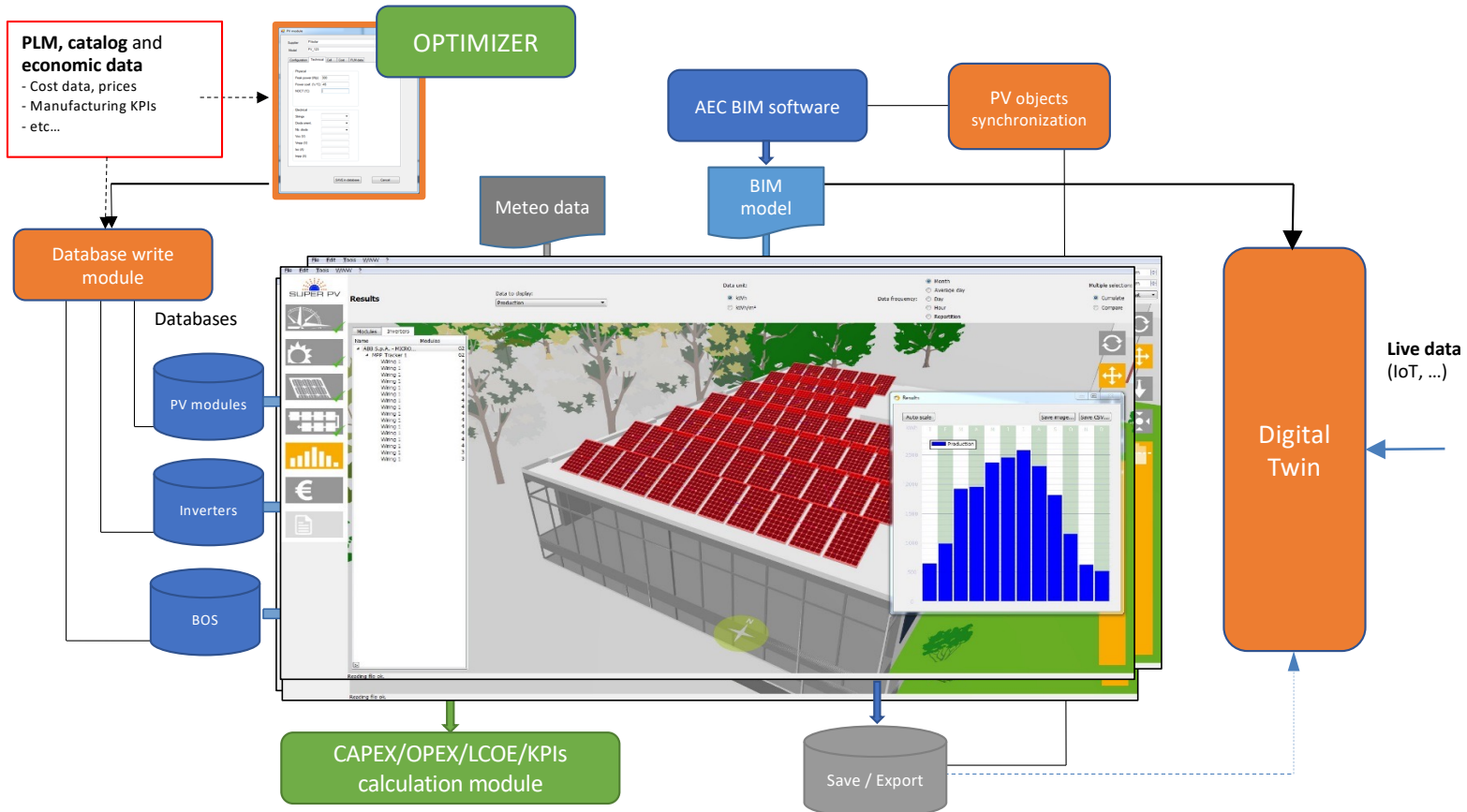
Product & plant Twin



Performance Twin



WORKFLOW & development: BIPV BIM platform




CONCEPT DESIGN: VIRTUALIZING BIPV PANELS

BIPV means multifunctional materials



BIMsolar Panel Editor: anticipating BIPV performance and BIM

 BIMsolar WEB

AboutPanel Editor3D sceneseCatalogLogin

You can test Panel Editor configuration features.
Please login to access more Panel Editor functions (load, save, publish ...).

COST SAVINGS:

- > Time to pre-design
- > No tool to install
- > Time to share discuss and decide

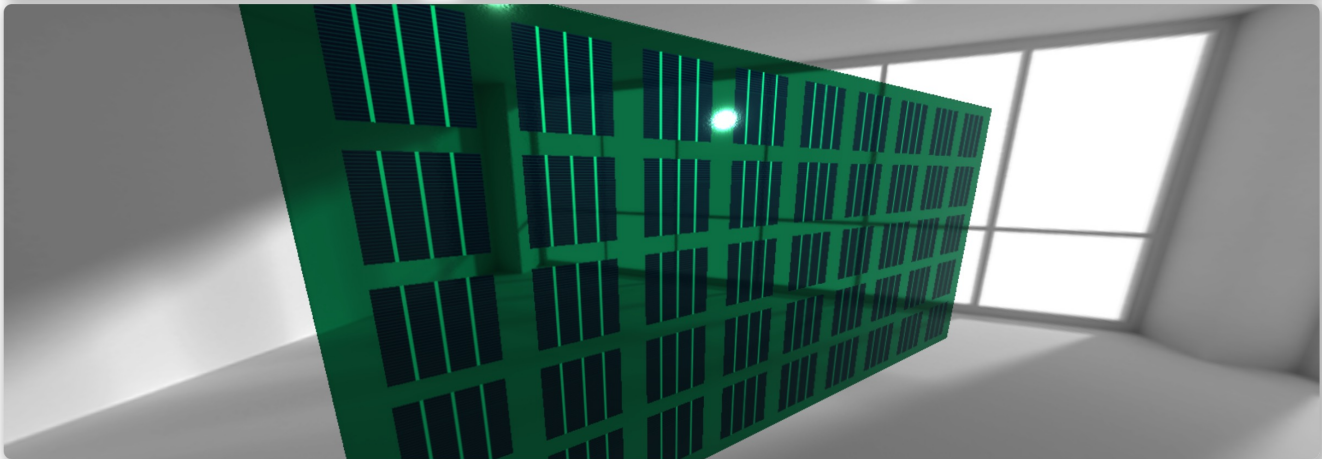
GAINS:

- > BIM ready objects
- > Main features to simulate BIPV layout
- > 1st cost assessment
- > 1st carbon impact

Max Cells : 72
Current Cells : 45

Panel Area : 2 m²
Active Area : 1.11 m²
Free Area : 44.5%

Total Power : 135 W
Panel Impact CO₂ eq : 144.3 kg
Panel Cost : 481 €



Design

Compare

Share

Integrate

Perform

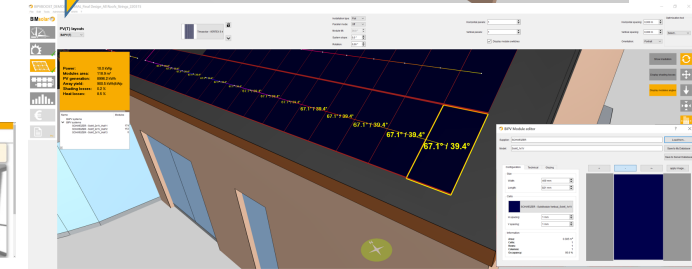
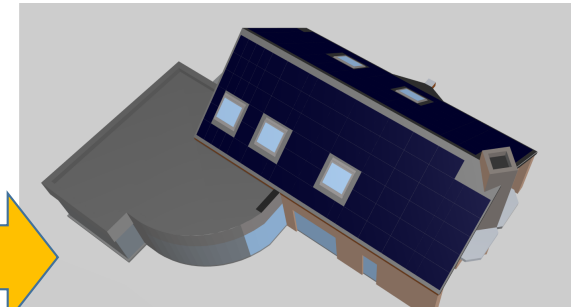
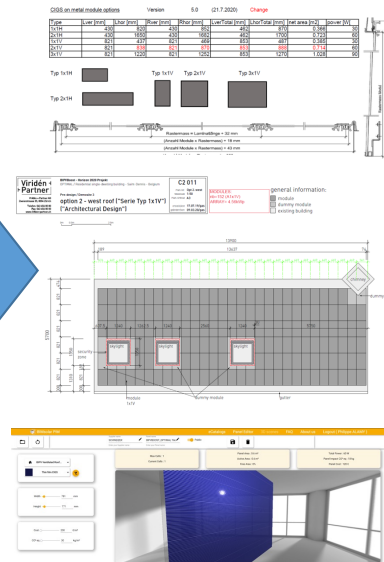
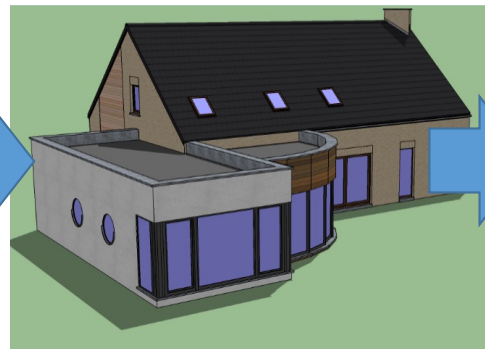
CONCEPT DESIGN: MATERIALS MUST INTEGRATE BUILDINGS

BIPV needs multidisciplinary tools and studies



From panel editor to Total BIM: collaborative workflows

BIM + solar tools import either non-BIM or BIM CAD models to support BIPV concept designs



Concept Design

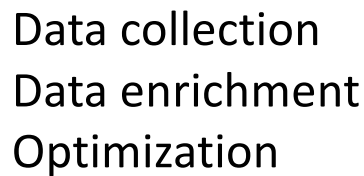
Technical Design

Manufacturing

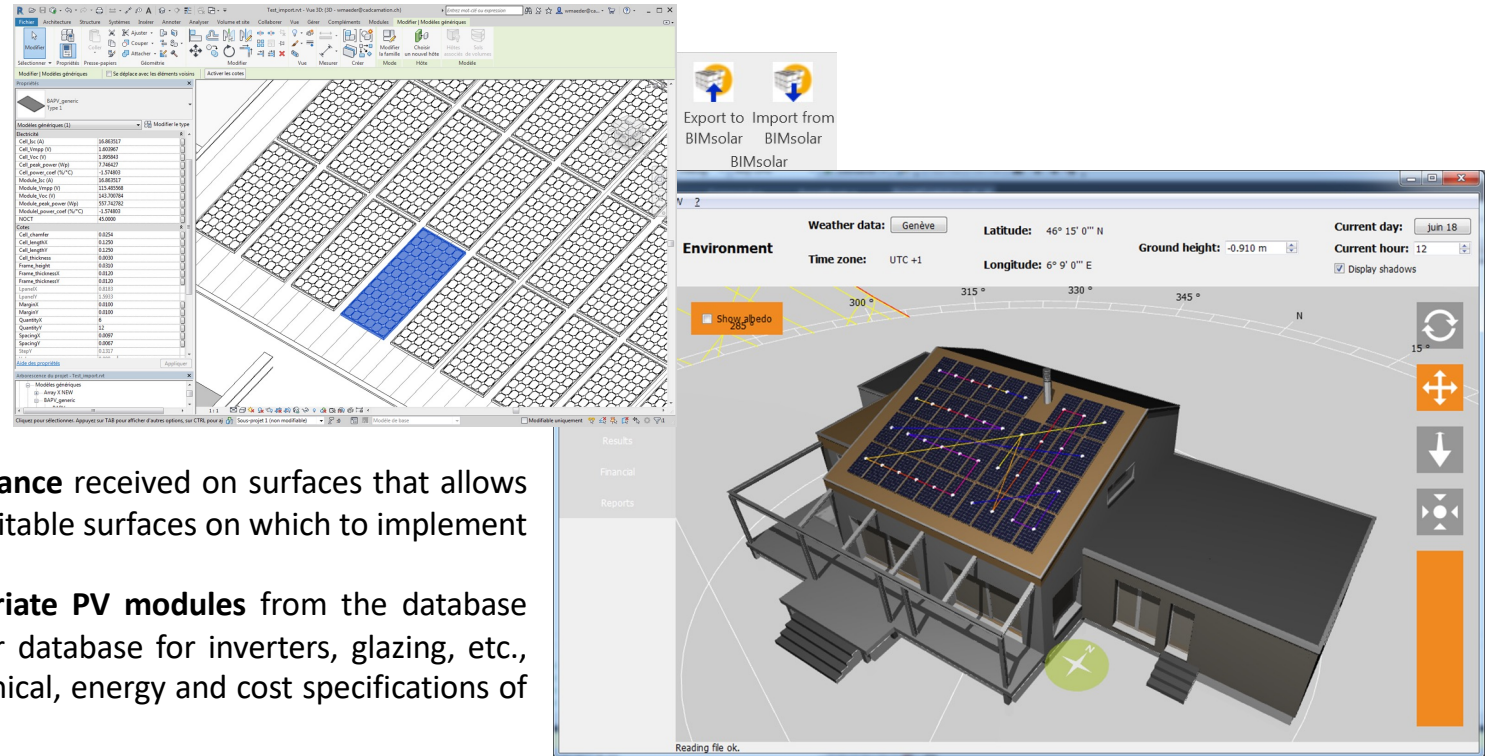
Installation

O&M

BIPV needs multidisciplinary tools and studies



- **Calculation of local solar irradiance** received on surfaces that allows the user identifying the most suitable surfaces on which to implement the BIPV system.
- **Selection of the most appropriate PV modules** from the database (BIPV modules as well as other database for inverters, glazing, etc., including the geometrical, technical, energy and cost specifications of each element)



STEP BY STEP ENRICHED DESIGN

BIPV needs multidisciplinary tools and studies



BIM + solar: a 7-steps collaborative process to assess BIPV solutions

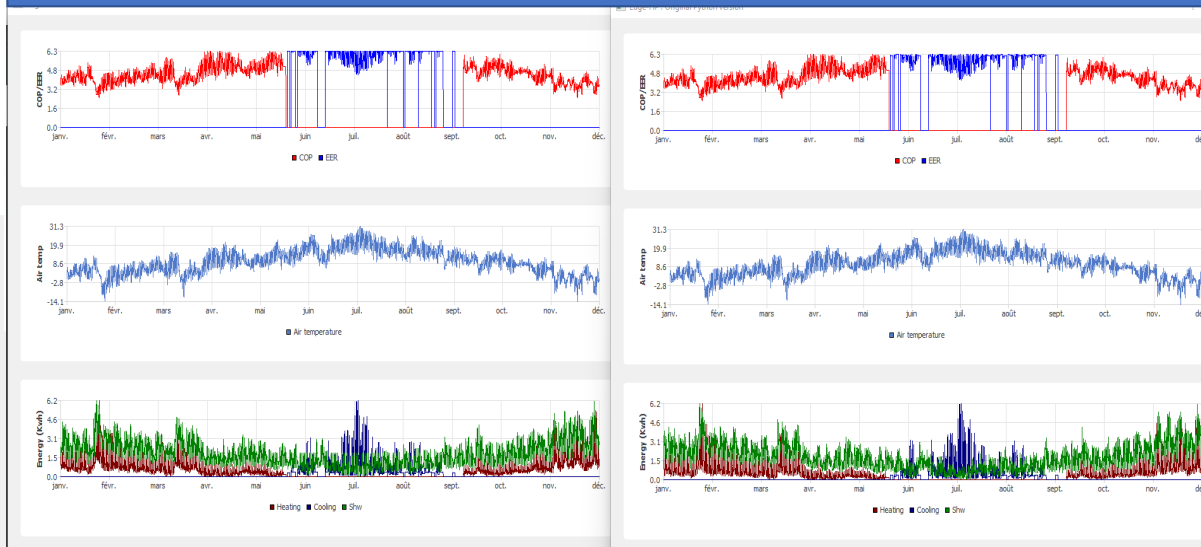
COST SAVINGS:

- > Time to pre-design
- > Time to optimize
- > Risk of avoiding issues
- > Time to share discuss and decide

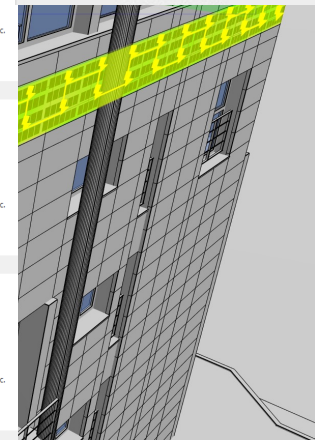
GAINS:

- > BIM ready layouts
- > Unique workspace
- > Multiple KPIs
- > Modularity (plugins)

OPTIMAL+EURAC modules to optimize technical+economic studies



Export to BIMsolar
Import from BIMsolar
BIMsolar



Concept Design

Technical Design

Optimization

Decision

Technical Design

ONGOING DEVELOPMENTS



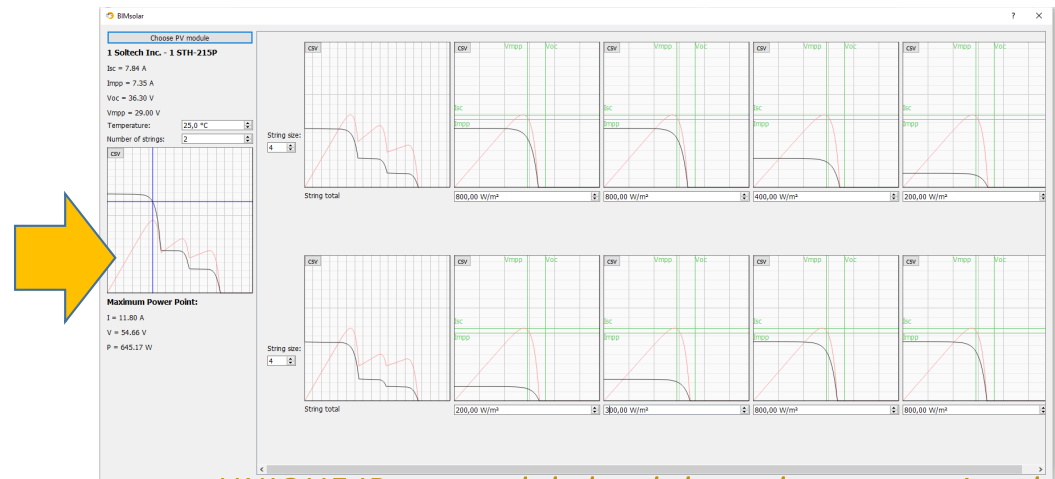
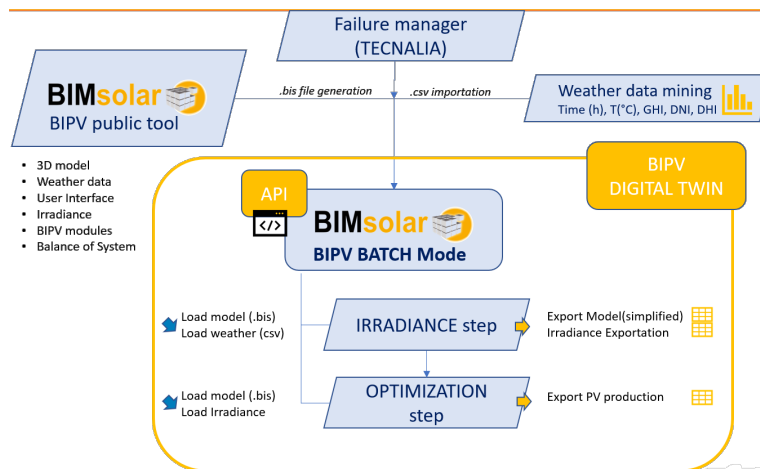
ANTICIPATE OPERATIONS & MAINTENANCE

ONGOING DEVELOPMENTS



BIMsolar DT: the unique Digital Twin addressing BIPV O&M

BIMsolar projects are translated into analytic models (I/V) to perform FMEA



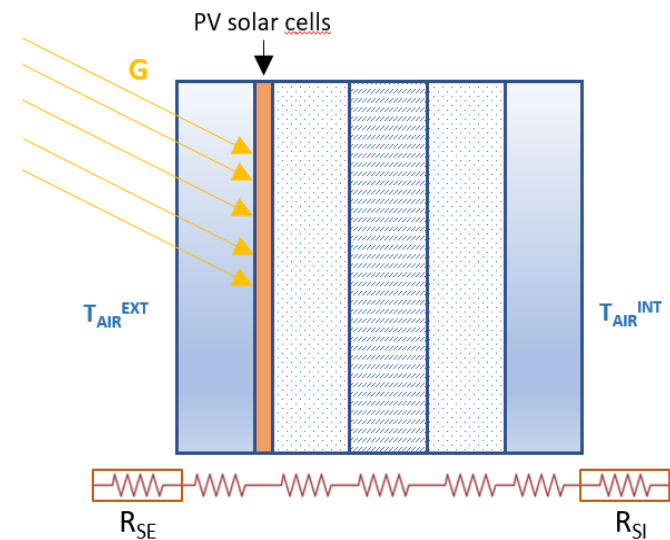
UNIQUE IDs at module level through computational analysis

Concept Design > Technical Design > Manufacturing > Installation > O&M

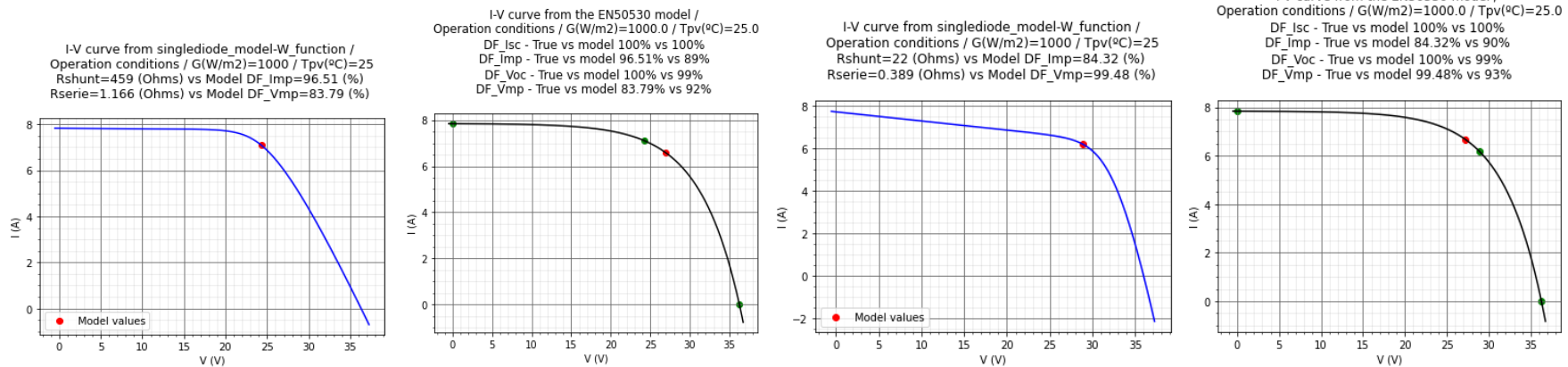
BIMSOLAR BIPV DIGITAL TWIN API: INPUTS

ONGOING DEVELOPMENTS

Inputs	Level
Time (t)	System
Irradiance (G)	System
Ambient temperature (Ta)	System
Irradiance loss (Lg)	Submodule
Short-circuit current (Isc_stc)	Submodule
Open-circuit voltage (Voc_stc)	Submodule
MPP current (Impp_stc)	Submodule
MPP voltage (Vmpp_stc)	Submodule
Current temperature coefficient (alfa)	Submodule
Voltage temperature coefficient (beta)	Submodule
NOCT	Submodule
Series resistance (Rs)	String
Conversion efficiency (η)	Inverter
MPP voltage deviation (delta_Vmpp)	Inverter



I/V management: the choice of models coupling



Input parameters
(values at STC)
 I_{sc} , V_{oc} , I_{mp} , V_{mp} ,
 $TC[V_{oc}]$, $TC[I_{sc}]$

Initial guess of single
diode parameters: R_s ,
 R_{sh} , I_L , I_0 , n

Obtaining R_s , R_{sh} , I_L , I_0 , n
for working operation
conditions – Solving
systems 5 eq. & 5 param.

Solving I-V curve at
operation conditions –
Lambert W-function

Brief explanation of the study-cases to test the five-parameters diode model
(parameters and operation conditions used to generate I-V curves)

I-V curves have been generated from the five-parameter diode model by using the PVLIB library. The resolution of the electrical model equation was carried out by using the Lambert W function

The I/V challenge

- The digital thread development is 80% achieved (BIPVBOOST+SUPERPV H2020 projects)
- TECNALIA investigated new methods to calibrate the DT parameters at PV module level from monitoring information at string level and irradiance distribution from BIMsolar
- We deduced the root causes behind the detected deviations of the different parameters of the DT:
 - Influence of module position/orientation: irradiance modelling, temperature, optical models
 - need to put more effort on I/V algorithms from equations, experimentation (test benches, materials), and software integration

The upcoming projects

- Synthetic data with different combinations of failure modes will be generated to test these improvements at development stage
- Work on displaying the results from calibration, fault detection and diagnosis processes, offering the end users a visual and comprehensive interface.
- Check parameters indicating the State of Health of every single PV module and alarm reports at the system level
- Include an interface to input pseudo-real-time measurement data (such as global, diffuse, and direct irradiation)
- Integrate real consumption profiles from BEMS and provide self-sufficiency analysis



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**Thank you for
your attention!**

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