SMART GRID PROTECTION AGAINST CYBER ATTACKS

Example of a Cyber-Physical Attacks Investigation on IEC 61850/61499 equipped PV Inverters using 4DIAC

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IEEE 1951-2011 60th anniversary

EU FP7 Programme Contract No. 608224

Outline

- About FP7 SPARKS
- Recent cyber-attacks
- IEC 61850 smart grid environment
- IEC 61850/61499 PV remote control in 4DIAC
- Cyber-attack scenario
- Conclusions

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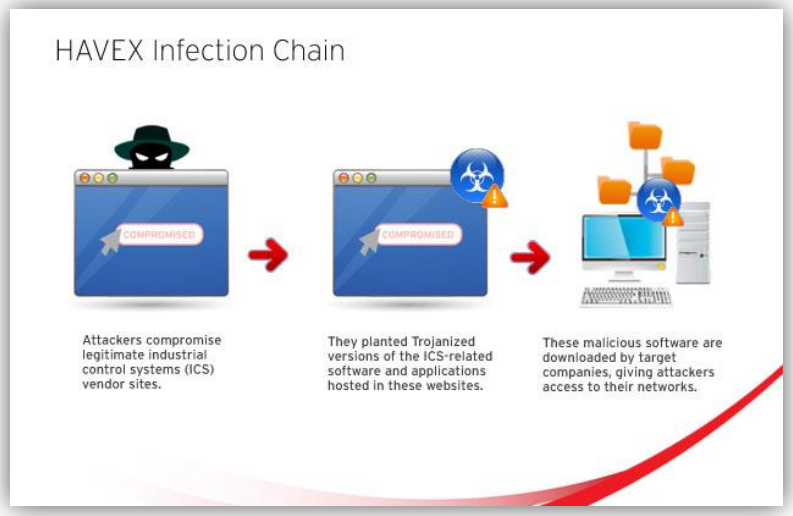
About FP7 SPARKS

SMART GRID PROTECTION AGAINST CYBER ATTACKS

- FP7 project deals with smart grid cyber security
- Objectives
  - Engage stakeholders and perform demonstrations
  - Analyze smart grid security and risk
  - Propose smart grid security standards
  - Develop security measures and procedures
  - Investigate financial, legal and social issues
- Project details
  - Funded by European Union (EU) under FP7, SEC-2013.2.2-3 Protection of smart energy grids against cyber attacks
  - Contract No. 608224,
  - Start Date: 1st April, 2014, duration of 3 years

Recent Cyber-Attacks

- "Black Energy"
  - Malware discovered on internet-connected HMIs
  - Targets HMI products from three vendors: GE, Siemens, BroadWin
- "Havex" Remote Access Trojan (RAT)
  - Targets OPC communications
  - Client/server technology widely used in process control systems



Ref: Trend Micro

Recent Cyber-Attacks

- German steel plant
  - ‘Spear phishing’ emails and social engineering techniques
  - Login credentials obtained
  - Access gained to the plant office network ...

    and then to the production systems
  - Blast furnace could not shut down as normal
  - Caused “massive damage”

→ *Attackers showed technical expertise*

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Recent Cyber-Attacks

- Take Away Message

Cyber attack

but ...

Physical impact

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IEC 61850 Smart Grid Environment

- AIT SmartEST laboratory
  - Test laboratory for distributed energy resources (DER) in SPARKS
  - Specialized in inverter tests and system tests with multiple components and environmental testing capabilities

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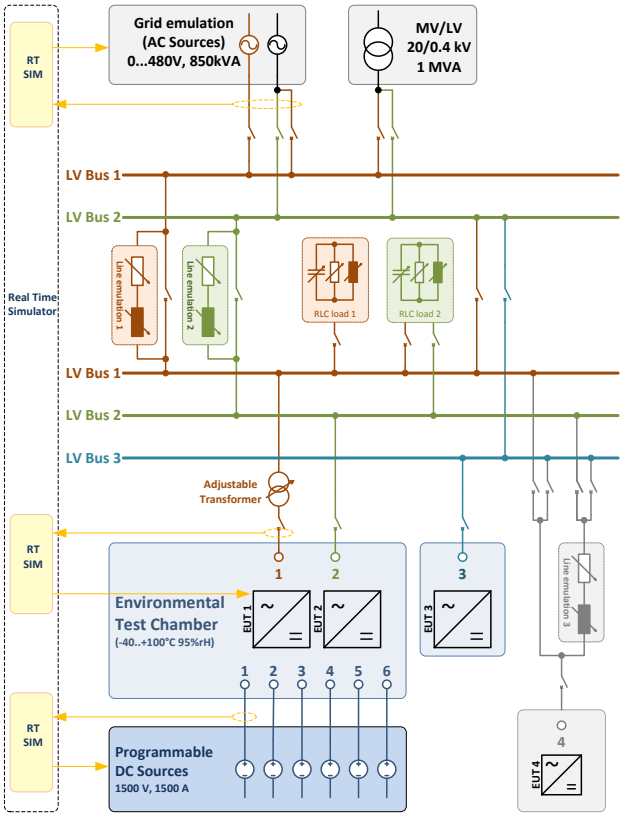
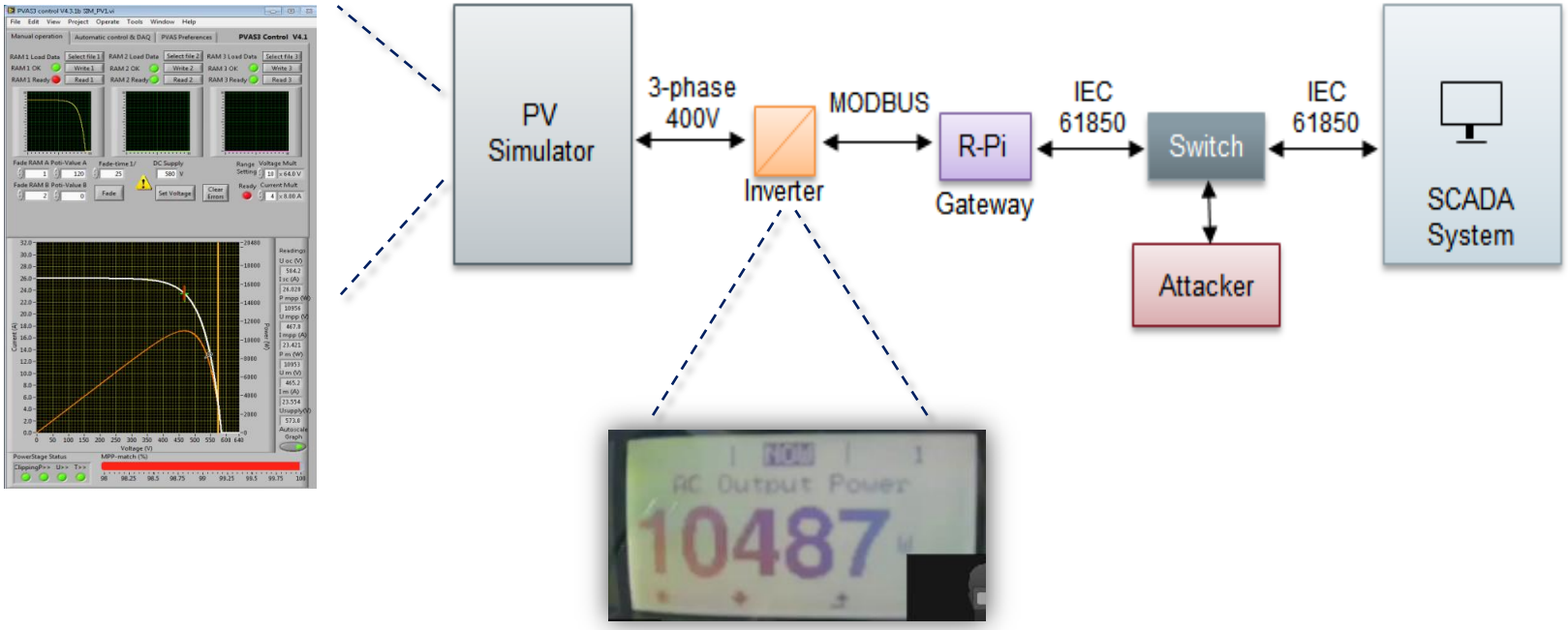
IEC 61850 Smart Grid Environment

- Electrical layout
  - Low voltage (LV) (400 V) laboratory
  - Supplied by local 20 kV medium voltage grid
  - Testing single DER components (e.g. PV inverters up to the 800 kW)
- DC sources (PV array simulation)
  - Independent dynamic PV-Array simulators (5x 1500 V, 1500 A, 960 kW)
- SCADA and automation system
  - Highly customizable laboratory automation system based using IEC 61499/4DIAC
  - Remote control possibilities of laboratory components



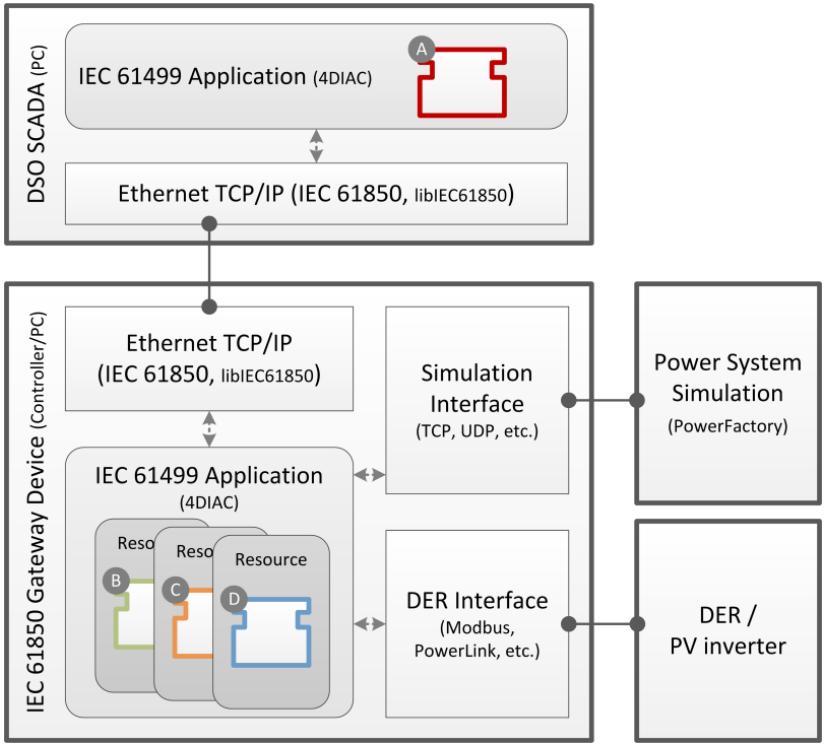
IEC 61850 Smart Grid Environment

- Simple overview of attack scenario



IEC 61850/61499 PV Remote Control

- 4DIAC implementation
  - IEC 61850 interface for PV inverters realized with IEC 61499/4DIAC



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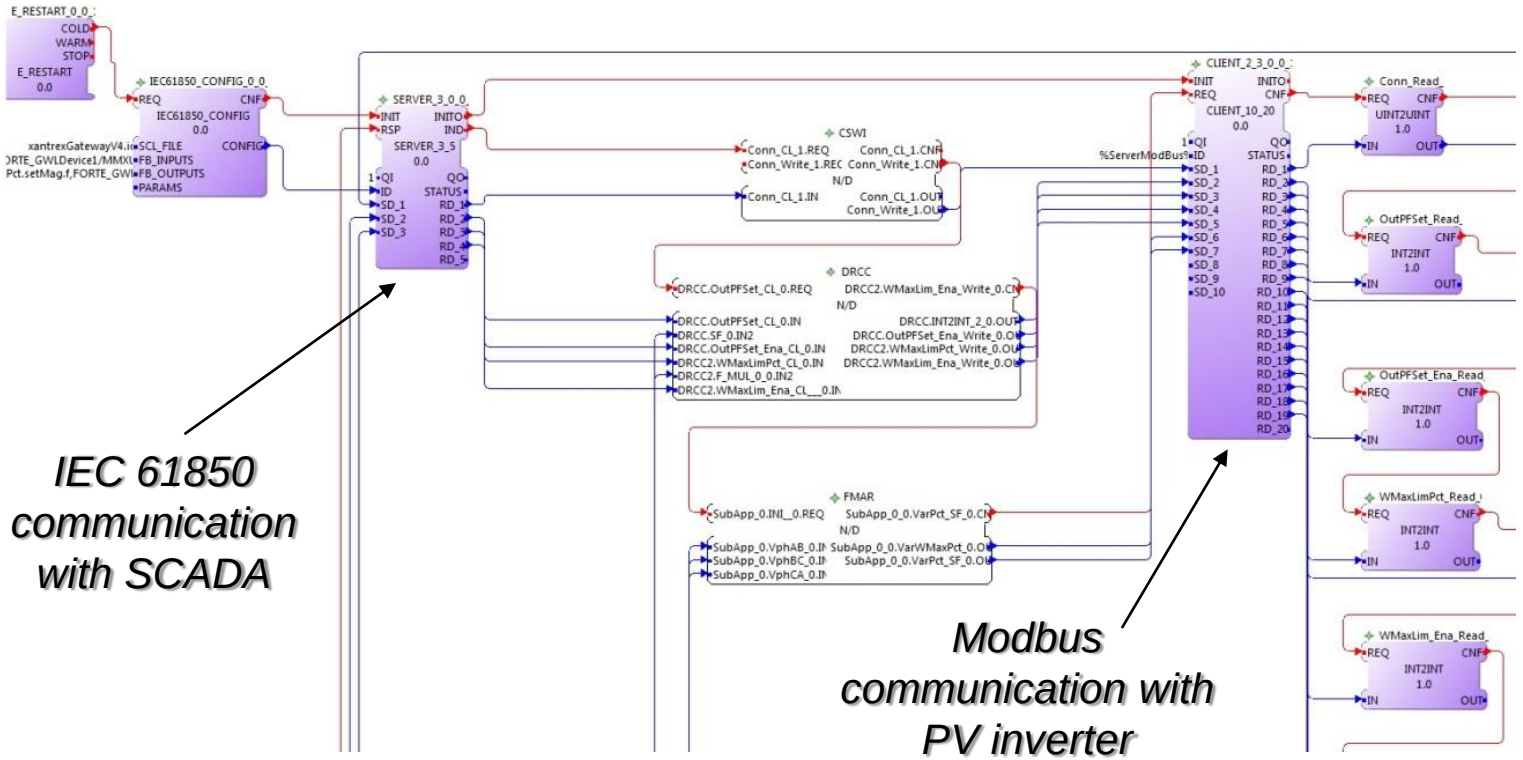
IEC 61850/61499 PV Remote Control

- 4DIAC implementation
  - IEC 61499 application using IEC 61850 and Modbus communication



IEC 61850/61499 PV Remote Control

- Used validation setup with the Raspberry Pi

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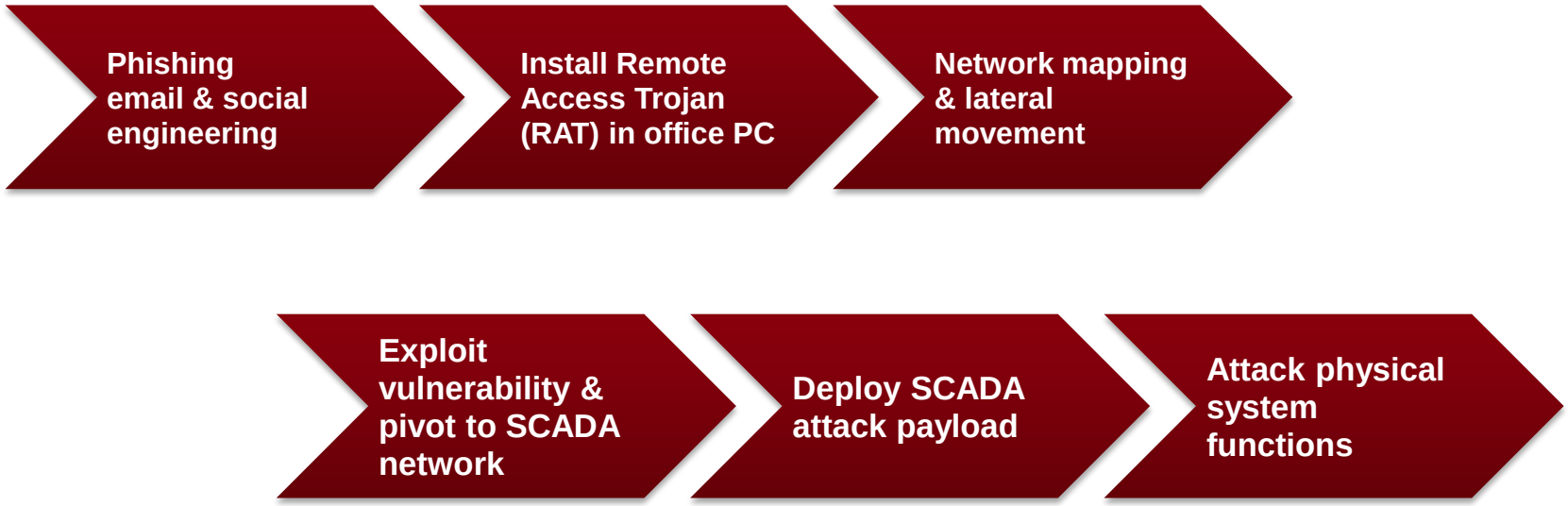
Cyber-Attack Scenario

- SPARKS demonstration scenario ...

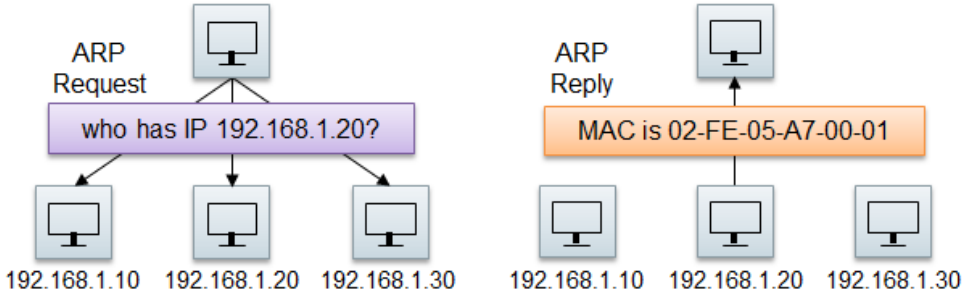


→ *Details are provided at the SPARKS website*

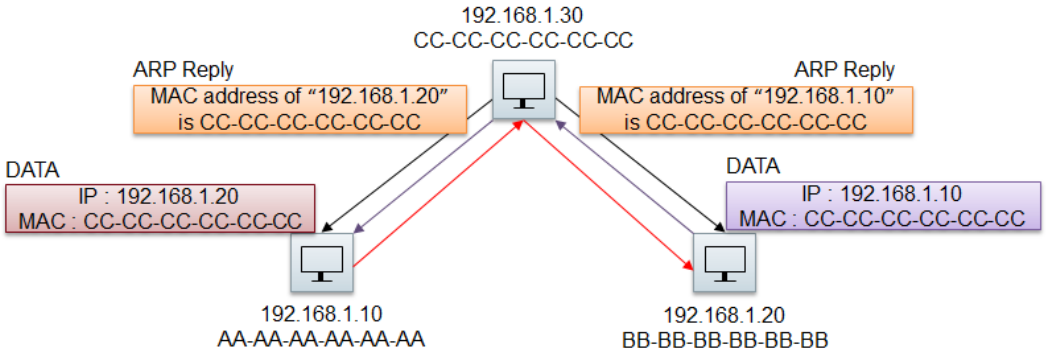
Cyber-Attack Scenario

- Man-in-the-middle (MITM) attack

Address Resolution Protocol (ARP)



ARP Poisoning

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[1] 10.55.55.121 -> 10.55.55.111
[2] 10.55.55.111 -> 10.55.55.121
[3] 10.55.55.121 -> 10.55.55.111
[4] 10.55.55.111 -> 10.55.55.121

!!!Injection : 10.55.55.121 -> 10.55.55.111

[5] 10.55.55.111 -> 10.55.55.121

!!!Packet Drop


!!!Injection : 10.55.55.121 -> 10.55.55.111

[6] 10.55.55.111 -> 10.55.55.121

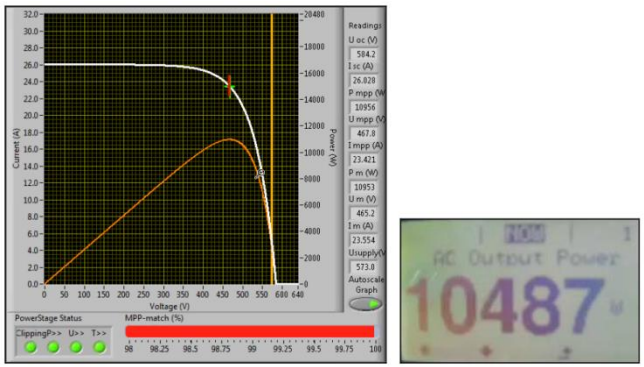
!!!Packet Drop

[7] 10.55.55.121 -> 10.55.55.111
[8] 10.55.55.111 -> 10.55.55.121
```

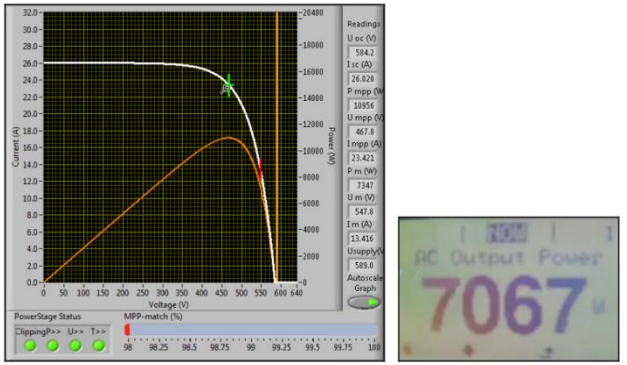
Attacker Interface (based on Ettercap)

Cyber-Attack Scenario

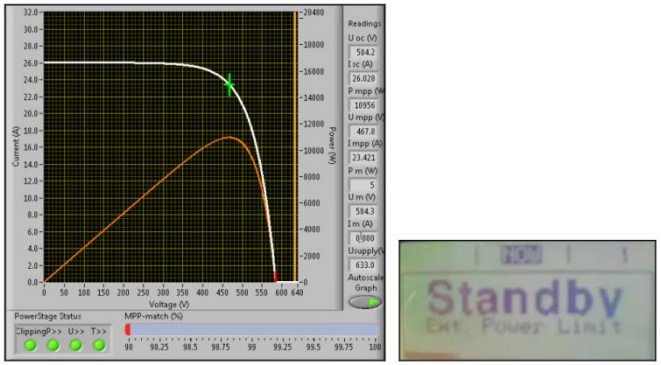
- Physical impact on PV inverter
  - Attack (manipulation) of inverter set-points (active power)



(a) 100% of power limitation by the operator



(b) 60% of power limitation by the operator



(c) 10% of power limitation by the attacker

Conclusions

- Recent cyber-attacks showed
  - Control systems are being specifically targeted
  - Attackers display technical knowledge of underlying communications, control systems and physical systems
  - Trajectory is towards selective intrusions and tailored attacks
- Better understand the physical consequences of cyber-attacks needed
- Analysis of cyber-attacks in the laboratory context in FP7 SPARKS
  - IEC 61850/61499 gateway implementation for cost-affective upgrade possibility of PV inverters implemented in 4DIAC
  - Existing PV inverters become IEC 61850 compliant
  - Cyber-attack scenario made in the AIT SmartEST lab