Holistic system integration and validation procedure developed in ERIGrid

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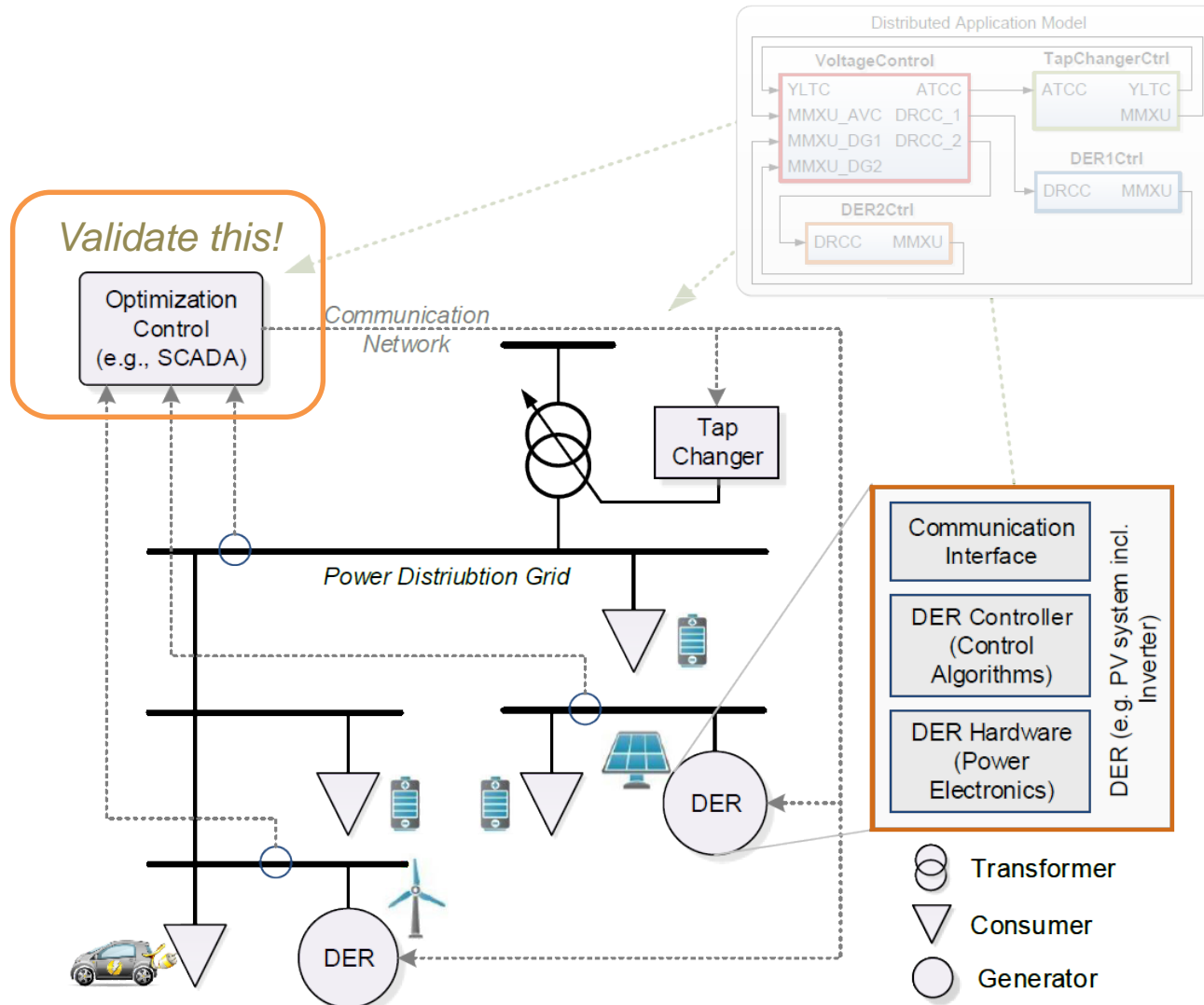AIT Austrian Institute of Technology, Vienna, Austria

*Workshop "Holistic System Validation, Methods
and Tools, Free Access to Best Smart Grid Laboratories"*

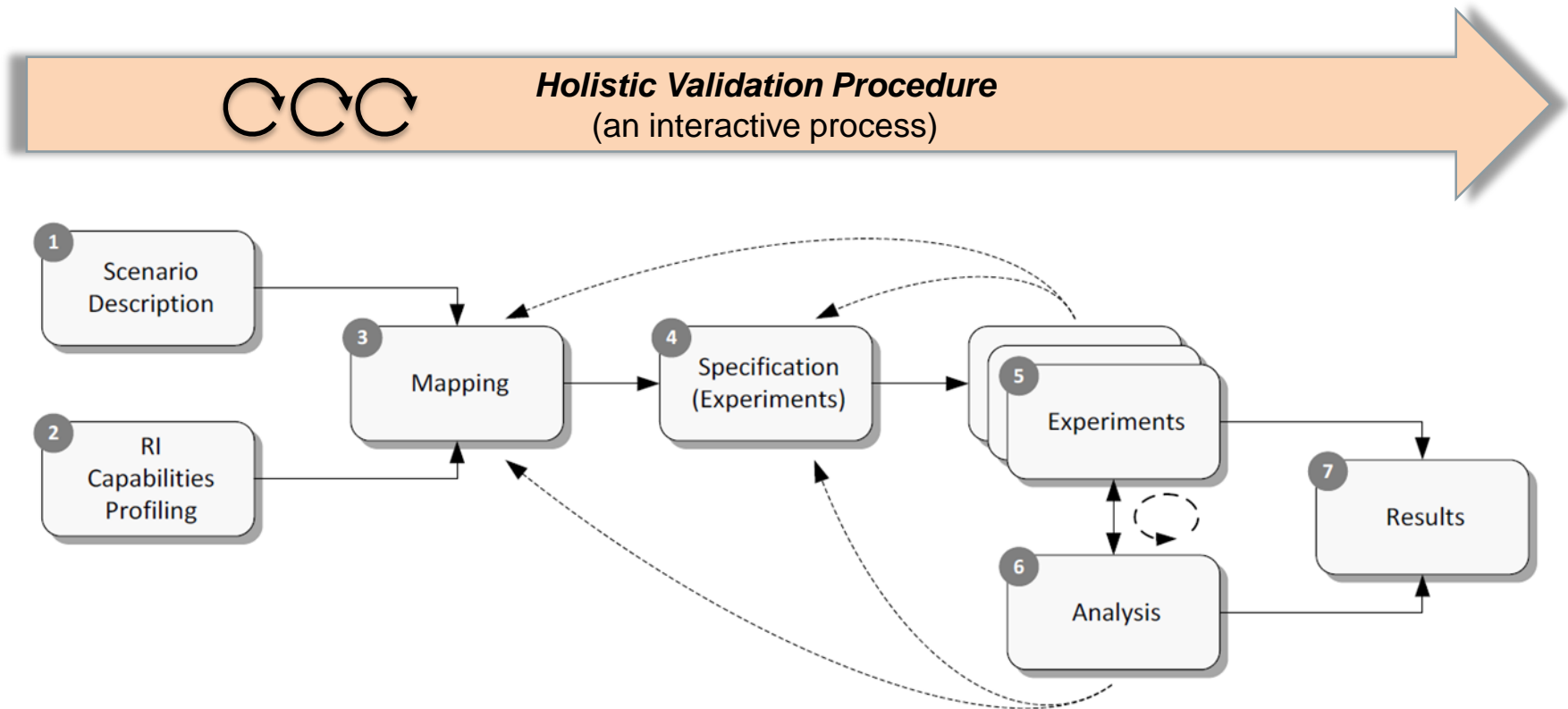*October 5, 2017, Amsterdam, The Netherlands*

European
Utility Week

3 - 5 October 2017, Amsterdam

Coordinated Voltage Control (CVC)
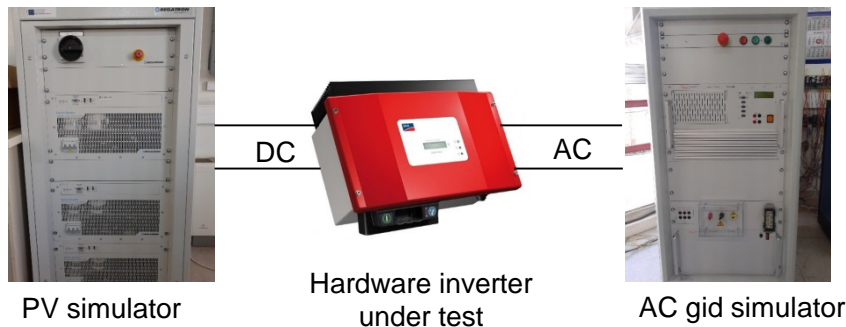
Holistic Testing & Validation

Holistic Validation Procedure
(an interactive process)

1. Scenario Description
2. RI Capabilities Profiling
3. Mapping
4. Specification (Experiments)
5. Experiments
6. Analysis
7. Results

"**Holistic testing** *is the process and methodology for the evaluation of a concrete function, system or component (object under investigation) within its relevant operational context (system under test), corresponding to the purpose of investigation*"

Holistic Test vs. Component Test

Component Test

- Example: inverter MPPT test, anti-islanding

- No interactions with the system

- Usually open loop test (predefined voltage, frequency; setpoints are applied to the hardware under test)

PV simulator   Hardware inverter under test   AC gid simulator

Holistic/System Test

- Combining several tests (testing process)

- Using simulations
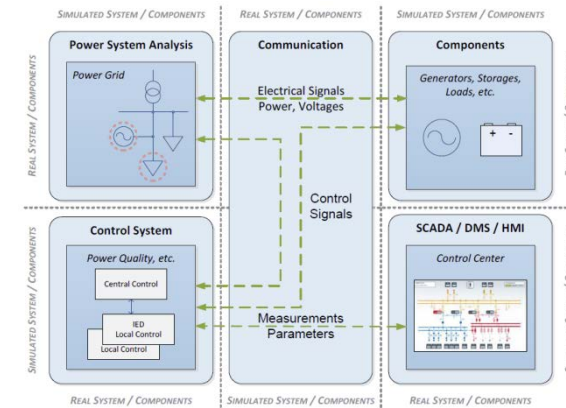
Figure 1.3: Improved methods and tools for Smart Grid validation and testing – possibility to combine virtual (simulated) and real components

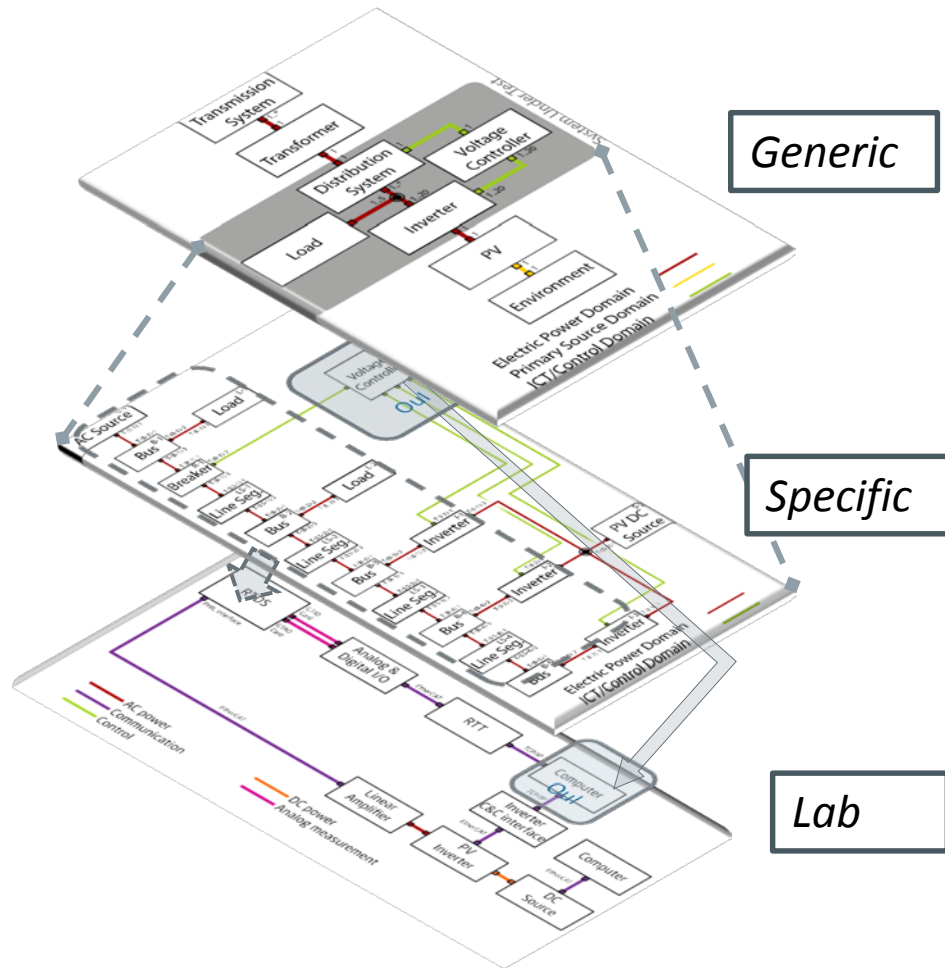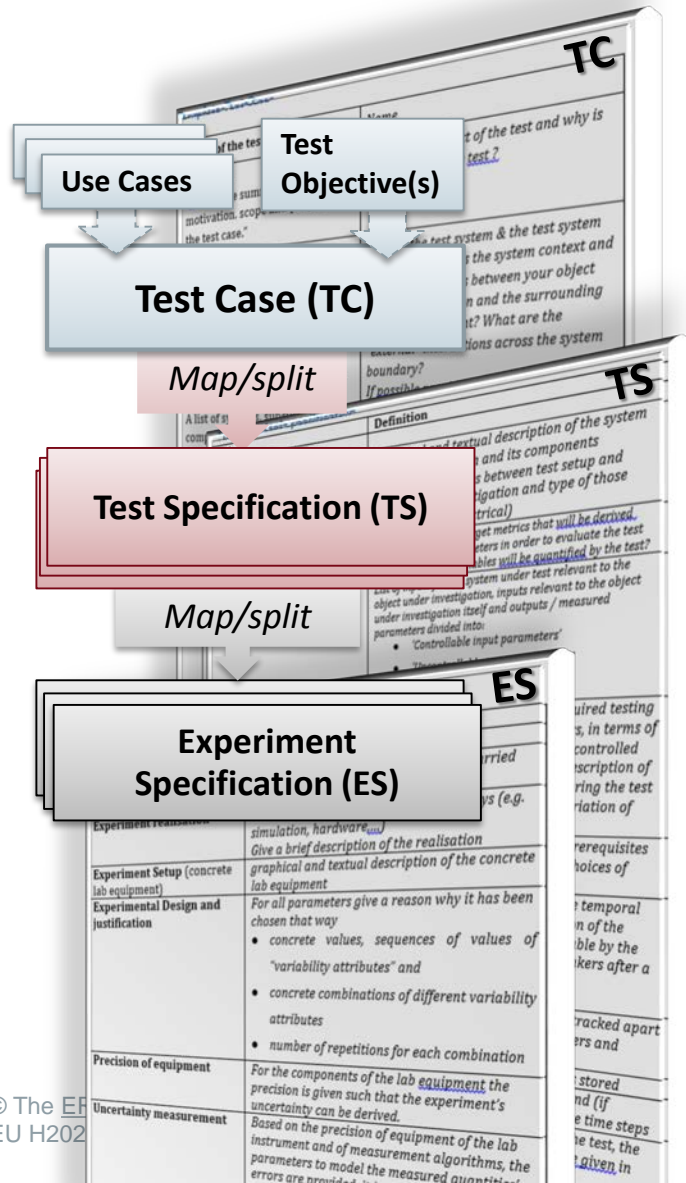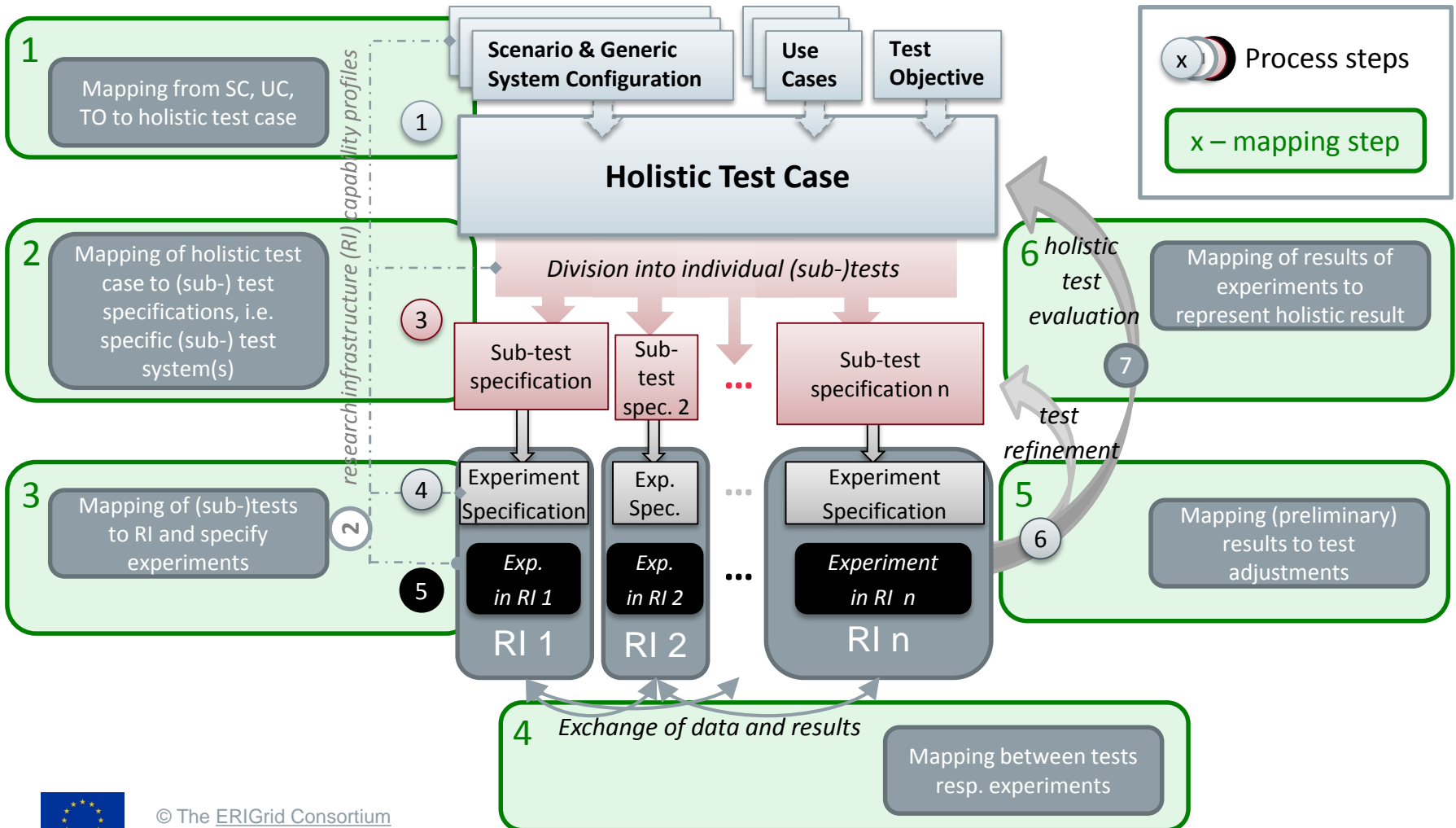- Testing a system rather than just component
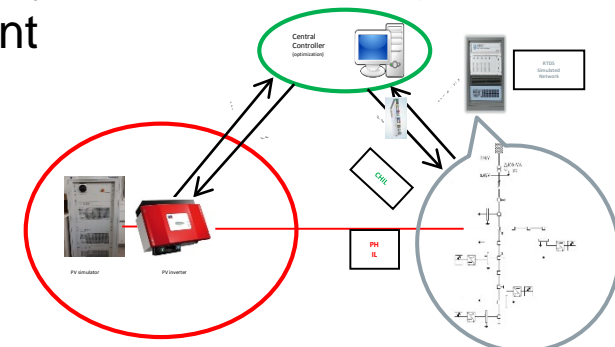
The basics

HOLISTIC TEST DESCRIPTION

Holistic test *description*

THREE levels of specification

TC

Use Cases

Test Objective(s)

Test Case (TC)

Map/split

TS

Test Specification (TS)

Map/split

ES

Experiment Specification (ES)

Generic

Specific

Lab

Holistic testing procedure – different mapping steps

Key Questions to be answered for **test specification**:
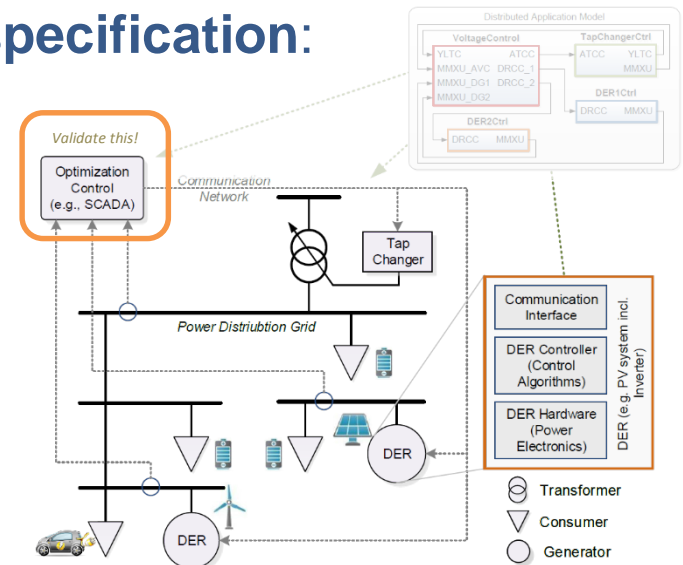
WHY TO TEST?
WHAT TO TEST?
WHAT TO TEST *FOR*?
HOW TO TEST?
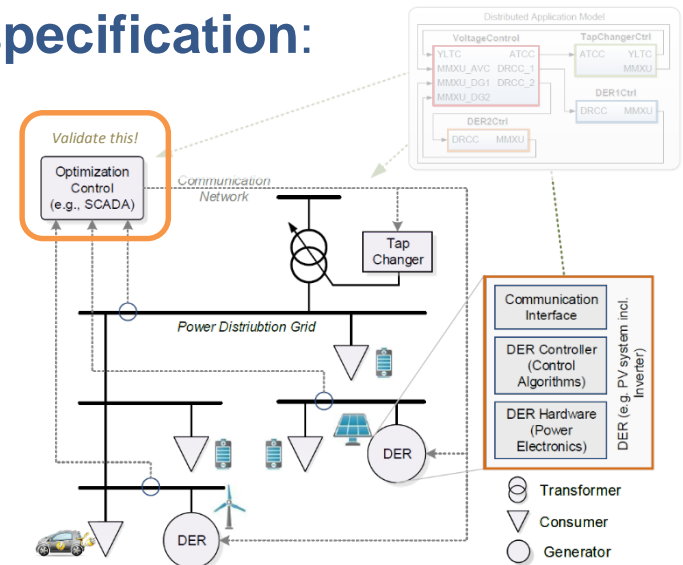
Key Questions to be answered for **test specification**:

WHY TO TEST?
WHAT TO TEST?
WHAT TO TEST *FOR*?
HOW TO TEST?

# Test **System & Domain**

System under Test (SuT):
is a <u>system configuration</u> that includes all relevant properties, interactions and behaviors (closed loop I/O and electrical coupling), that are required for evaluating an OuI as specified by the test criteria.

Object under Investigation (OuI): the component(s) (1..n) that are subject to the test objective(s).

    Remark: OuI is a subset of the SuT.

Domain under Investigation (DuI):
Identifies the domains of test parameters and connectivity relevant to the test objectives.
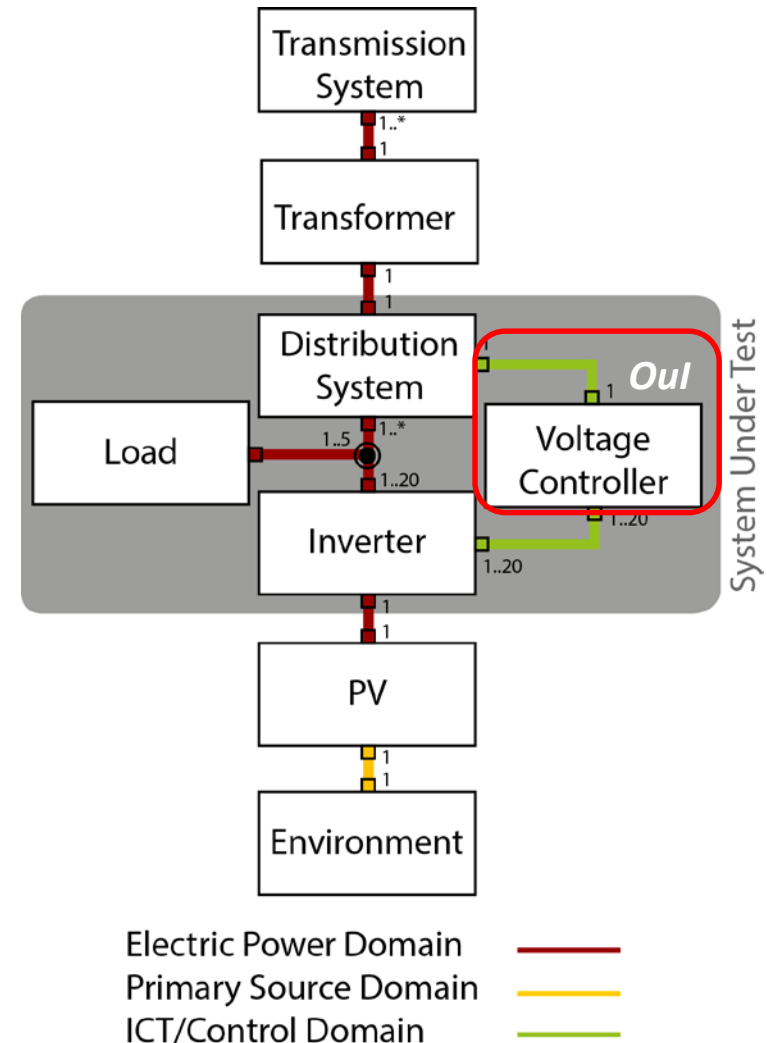
Test System **Functions**
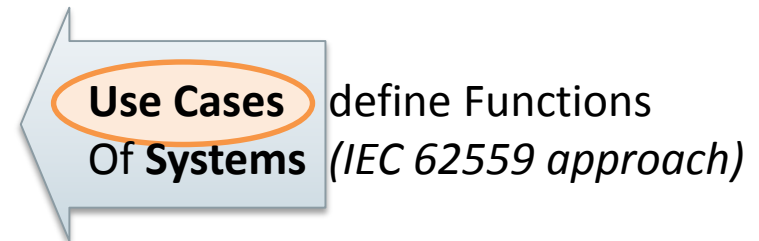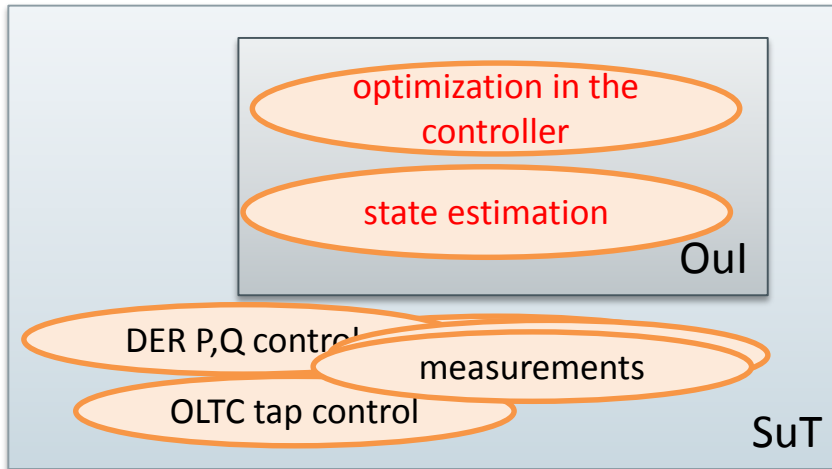
Functions under Test (FuT): the functions relevant to the operation of the system under test, as referenced by use cases.
Function(s) under Investigation (FuI): the referenced specification of a function realized (operation-alized) by the object under investigation.
Remark: the FuI are a subset of the FuT.

Key Questions to be answered for **test specification**:

WHY TO TEST?
WHAT TO TEST?
WHAT TO TEST _FOR_?
HOW TO TEST?

Purpose of Investigation (PoI)

- **Verification**

- **Validation**

- **Characterization**

Modeling / Understanding

Scoring / Performance

Test objectives/PoI: *Characterization and validation* of the DMS controller
1. Convergence of the optimization (*validation*)
2. Performance of the optimization under realistic conditions (*characterization*)
3. Accuracy of the state estimation (*characterization*)

Designing Test Criteria
Detailing Sequence

- **Test objective → PoI → Test Crit.**

- **Test criteria:** How to break down the PoIs?

  - *Target metrics* (criteria): list of metrics to quantify each PoI

  - *Variability attributes:* controllable or uncontrollable parameters to "disturb" SuT

  - *Quality attributes* (thresholds): test result level or quality of the TM required to pass or conclude the testing.

Target metrics:
1. 1.1 convergence (when/how often?), 1.2. How fast?, 1.3. solution quality
2. 2.1 Voltage deviation
    2.2 number of tap changes,
    2.3 network losses
3. Voltage, P, Q estimation errors

Variability attributes: Load patterns (realistic, annual variation; applies to criteria 1-3); Communication attributes (packet loss, delays)

Quality attributes (thresholds):
"1.2: convergence within 2 sec" (*validation*)
"3.* estimation quality characterized with confidence 95%" …

Key Questions to be answered for **test specification**:

WHY TO TEST?
WHAT TO TEST?
WHAT TO TEST *FOR*?
HOW TO TEST?

Test Specification & Design
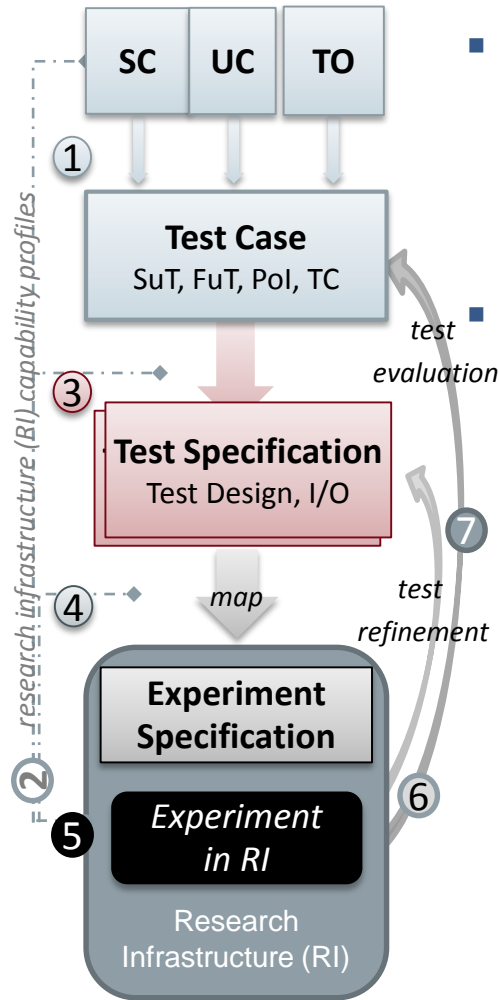
- **Given:**
  - ✓ Purpose of Investigation (PoI) & Test Criteria
  - ✓ System & Domain categories and relations

- **To Specify**:

  ❑ Precise system (specific system configuration)

  ❑ Which variables to manipulate & which to measure

  ❑ How to quantify the test metrics (based on test data)

     ❑ Sampling of the input spaces (design of experiments methodology)

     ❑ Combination and interpretation of the outputs

  ❑ The test design / procedure.

  ❑ Mapping to actual lab setup (experiement setup)

Detailing test setup & Mapping to the Lab

Scoping & specification of

test system.
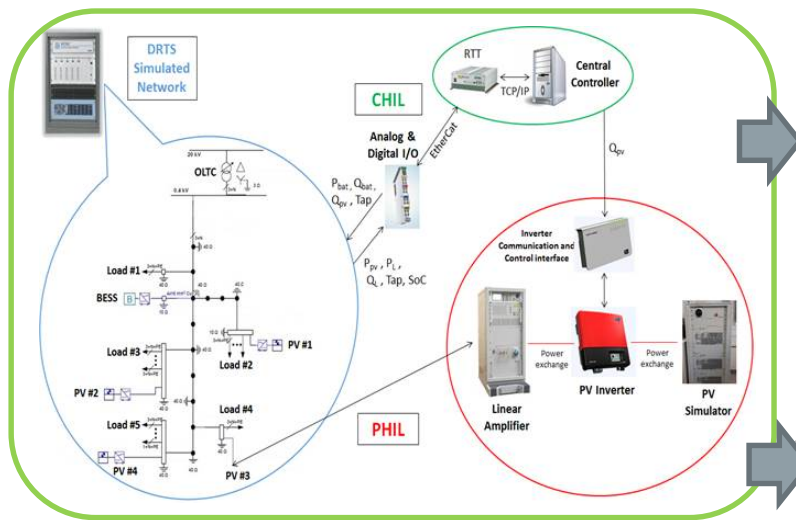
Separate specification

of lab implementation
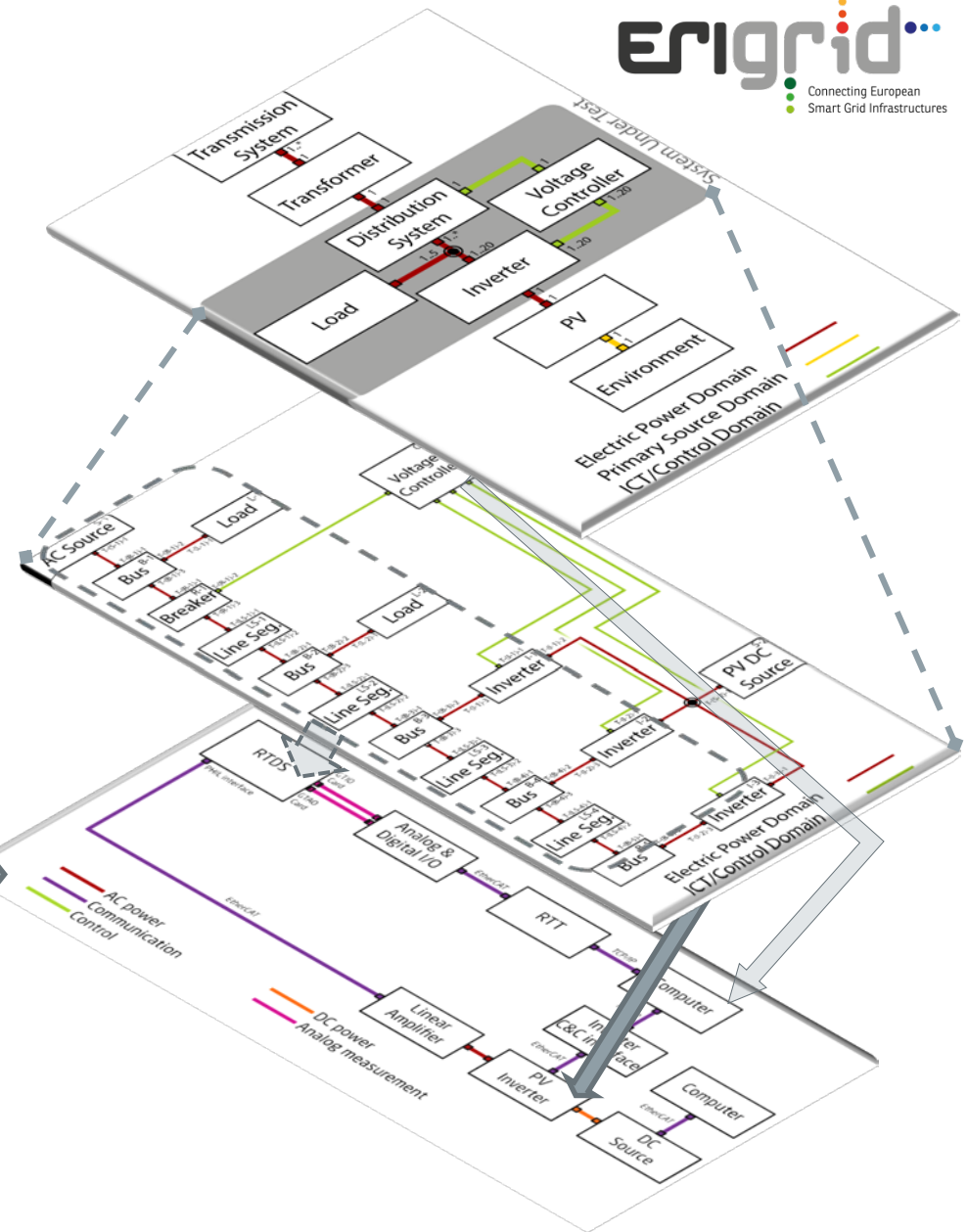
Can I just say, that it's very nice to get these questions sorted out now, rather than when you're sitting down and have to implement something.
You would then usually go "Oh shit, how does this work again?" – ERIGrid participant
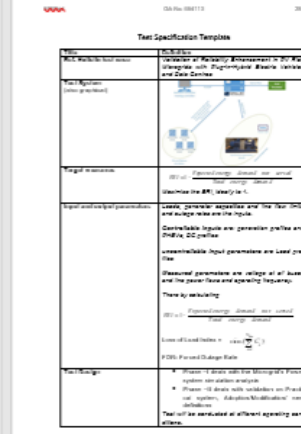
FIRST APPLICATION EXPERIENCE

ERIGrid Transnational Access:
Preparation & Documentation
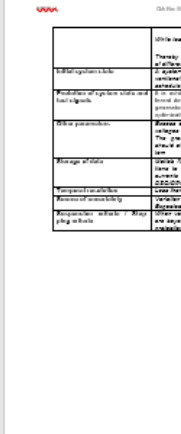
- External Lab users apply description procedure

- E.g. DiNODR – distribution network oriented application of demand response *– currently ongoing in SYSLAB*

- "The preparation work **helped us a lot**. Except minor changes in the plan and configurations due to a number of device, communication and control unavailabilities, we are **following our test and experiment specifications**. The template is also useful for our user team to **exchange ideas in an organized and effective** way. "
  - Alparslan Zehir (DiNODR)

Collaboration with other Projects

- ELECTRA IRP – Web-of-Cells (WoC) concept

  – Large set of use cases
     (distributed control)

  – Concurrent development
     and lab implementation

  – Specification of test cases and
     experiments

- SmartNet – TSO/DSO interaction

  – Different interaction schemes

  – Proof-of-concept lab validation
     and field testing

  – Specification of test cases and
     experiments

Summary and future work

- A clear vision for "holistic validation"

- Initial results

  – 3-level – test description template & guidelines

  – Multi-Domain System Configuration description (CIM compatible)

  – Several successful applications & encouraging feedback

- Future work

  – Further exemplify, simplify & detail description method

  – Develop & apply full holistic validation procedure