

# Introduction to International Test and Simulation Facility for Future Energy Systems

ISGAN/SIRFN International Smart Grid Workshop  
Brookhaven National Laboratory

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# ITSF Organization

A consortium has been constructed that has a strong smart grid track record



**DNV-GL** As per 2012 KEMA became part of DNV GL, a global provider of services for managing risk with more than 16,000 employees in over 100 countries. DNV GL Energy Advisory, present in over 30 countries around the world, is committed to driving the global transition toward a safe, reliable, efficient, and clean energy future.



**ICT** Automatisering ICT Automatisering is committed to enhancing clients' flexibility and operational simplicity, while improving their business, production and communication processes. It's a commitment that's possible by making available the highest levels of technological know-how. Know-how that we then deliver in the form of inventive and effective product/market combinations.



**TU/e** Eindhoven University of Technology (TU/e) is a research university specializing in engineering science & technology. We offer excellent teaching and research and thereby contribute to the advancement of technical sciences and research to the developing of technological innovations and the growth of wealth and prosperity both in its own region (technology & innovation hotspot Eindhoven) and beyond.



**vito** vision on technology As independent and customer-oriented research organization, VITO provides innovative technological solutions as well as scientifically based advice and support in order to stimulate sustainable development and reinforce the economic and social fabric of Flanders.



**TNO** innovation for life TNO is an independent research organization whose expertise and research make an important contribution to the competitiveness of companies and organizations, to the economy and to the quality of society as a whole. TNO's unique position is attributable to its versatility and capacity to integrate this knowledge.



**EnTranCe** ENERGY TRANSITION CENTRE The Energy Academy Europe provides education, conducts research and fosters innovation in the field of energy while working towards the transition to a sustainable energy future. The Energy Transition Centre (EnTranCe) is part of the EAE and serves as a field trial for applied research. It is initiated by BAM, GasTerra, Gasunie, Hanzehogeschool Groningen and Imtech.

# Positioning of the International Test and Simulation Facility (ITSF) for Future Energy Systems

ITSF mitigates the risks associated with the large scale implementation of smart grid and smart energy concepts by offering realistic simulation environments.

The energy transition in general, and smart energy concepts more specifically, will bring about new products, solutions, services and business models, that are often placed in distributed environments. The large scale installation / implementation of these concepts introduces substantial risks, as the impact of malfunctioning is large.

The International Test and Simulation Facility (ITSF) for Future Energy Systems provides services to manage these risks, by offering a complete test cycle that can be tailored to the customer's needs.

The large scale simulation environment is one of the core elements of the ITSF. It offers a unique testing environment, where the behavior and impact of products, solutions, services and business models can be assessed in a realistic smart grid environment, based on a wide range of future scenarios.

# Value proposition

The ITSF can address a wide variety of testing and simulation needs

**For** actors in the energy value chain

**who** need to assess the capabilities of products, systems or concepts in a simulated smart energy environment

**the** *International Test and Simulation Facility for Future Energy Systems*

**is** a testing and verification service

**that** is capable of assessing the behavior and effectiveness of the *system under test* by creating a simulated energy market and electricity grid, optimized through demand response, against different scenarios (energy mix, technology penetrations, distributed resources, etc.)

**Unlike** conventional testing services

**our** offering is able to create a realistic simulation environment by incorporating proven simulation modules (profile generator, energy market model, power flow model) and proven DR technologies, combined with measurement data from existing module tests and field trials

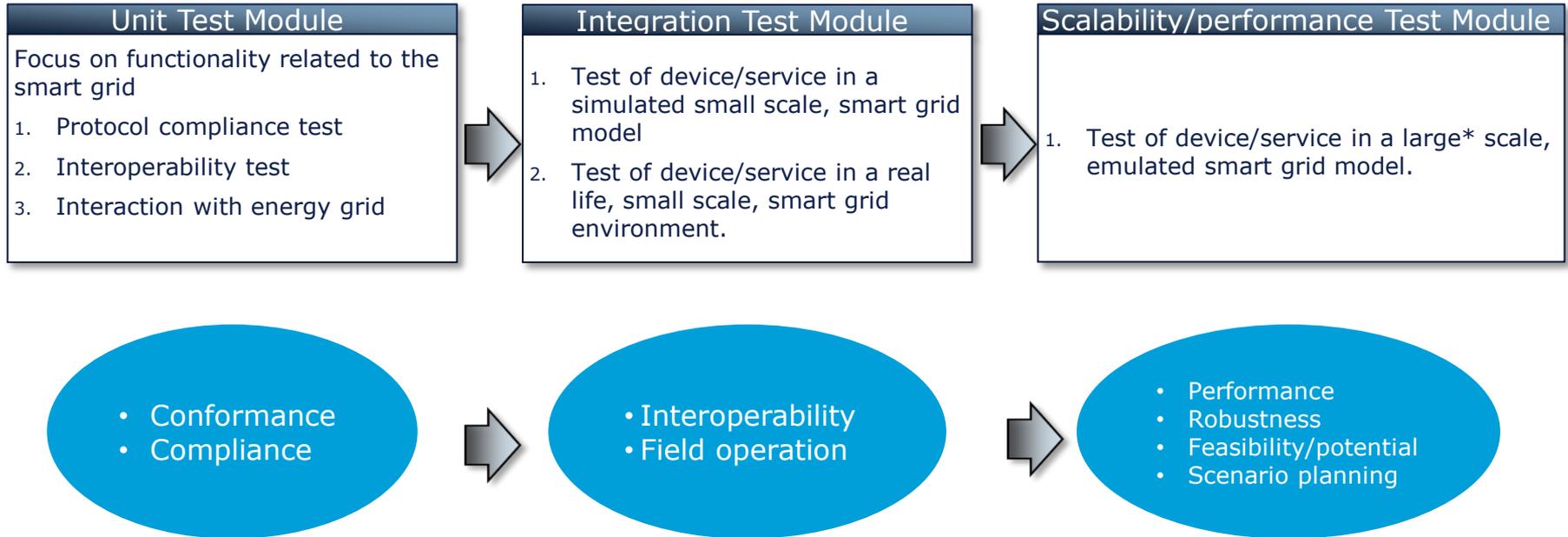
# Typical market needs addressed by the ITSF

ITSF is designed to address different testing needs by different stakeholders

1. Feasibility assessment of business models, centered around the concept of the aggregation and control of distributed load, generation and/or storage, eg.
  - Offering balancing services
  - Offering grid support
  - Offering in home optimization
2. Societal / economic system optimization through applying demand response, eg.
  - Optimal balancing under different scenario's
  - Economic feasibility of power to gas scenarios.
3. Testing of Solutions (software) on scalability aspects
  - Demand Response solution
  - Load shedding solution
4. Testing of system robustness
  - Behavior of the (agent based) system in critical or emergency situations
  - Behavior of the energy system when data manipulation occurs

# ITSF scope

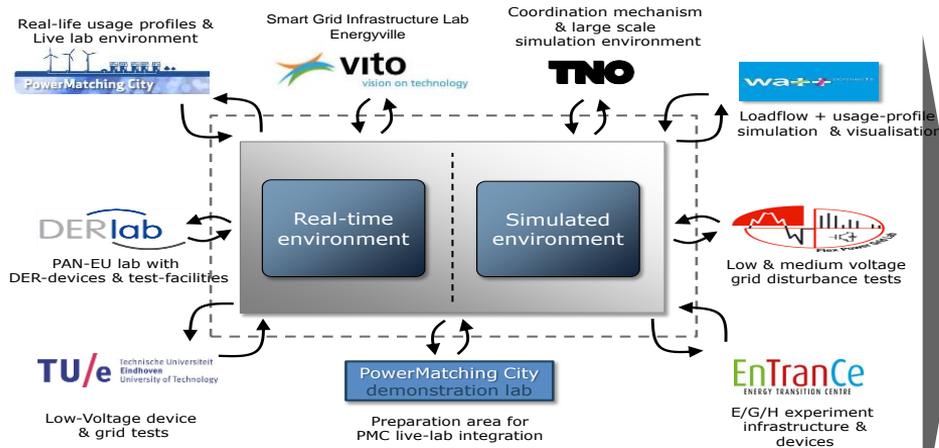
ITSF includes both real life and simulated smart energy test environments. The test cycle consists of three modules, from small scale unit testing to large scale simulation.



\* *Large scale* is considered an order of magnitude 10.000 – 100.000 customers.

# ITSF solution for the unit and integration testing

ITSF includes a wide range of testing facilities.

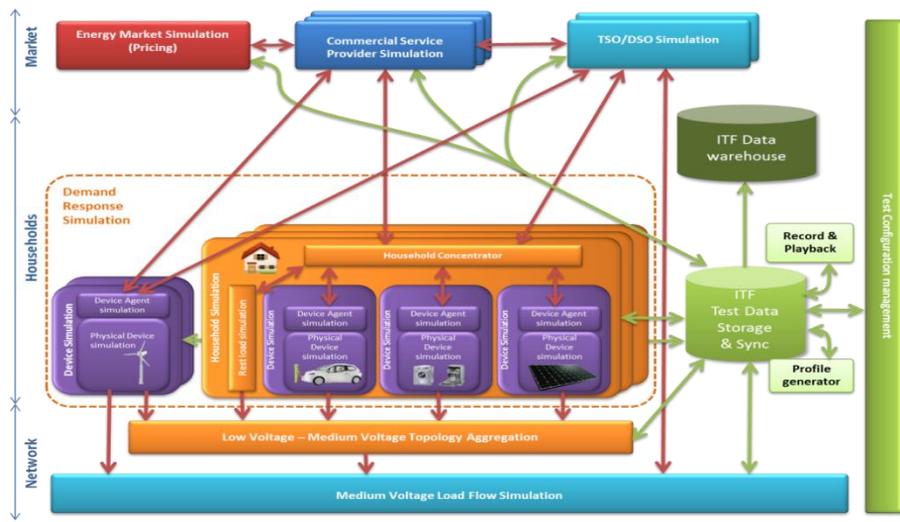


## Main elements

- The consortium partners already offer a variety of unit tests and integration tests
- Within ITSF, these facilities are integrated through a common Data Warehouse
- ITSF supports our customer in tailoring the test method to their specific needs.

# ITSF solution for the large scale environment

ITSF mitigates the risks associated with the large scale implementation of smart energy concepts by offering realistic simulation environments.



## Main elements

- The main focus within the large scale simulation tests is
  - Demand Response as a key element in the smart energy system
  - Impact on (and interaction with) the energy networks
  - Impact on (and interaction with) the energy markets
- The large scale environment allows for configuring future scenarios for aspects such as
  - Energy mix / penetration of renewables and distributed generation
  - Penetration of specific loads (EV, heat pump)
- Typical IT issues that can be revealed through scalability / performance testing are: deadlocks, latency issues, synchronicity, oscillation, behaviour in failure situations (e.g. communication breakdown).

# Unique selling points large-scale simulation environment

## *ITSF combines the following USPs*

- Realistic  
Simulation on unit/device level, showing realistic behavior (e.g. spikes, simultaneity)  
Inclusion of (future) load and generation, e.g. PV, EV charger, HR-E, Heat pump, wind.
- Specific  
Inclusion of actual LV/MV network topology, to assess the impact in “real” networks
- Dynamic  
Ability to assess impact (threats and opportunities) of demand response  
Ability to include closed-loops decision mechanisms
- Large scale  
Ability to simulate dwellings, LV grids and MV grids

# ITSF architecture (large scale simulation)

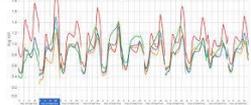
## Step 1: Scenario configuration



Grid topology



Scenario (technology, adoption, ...)



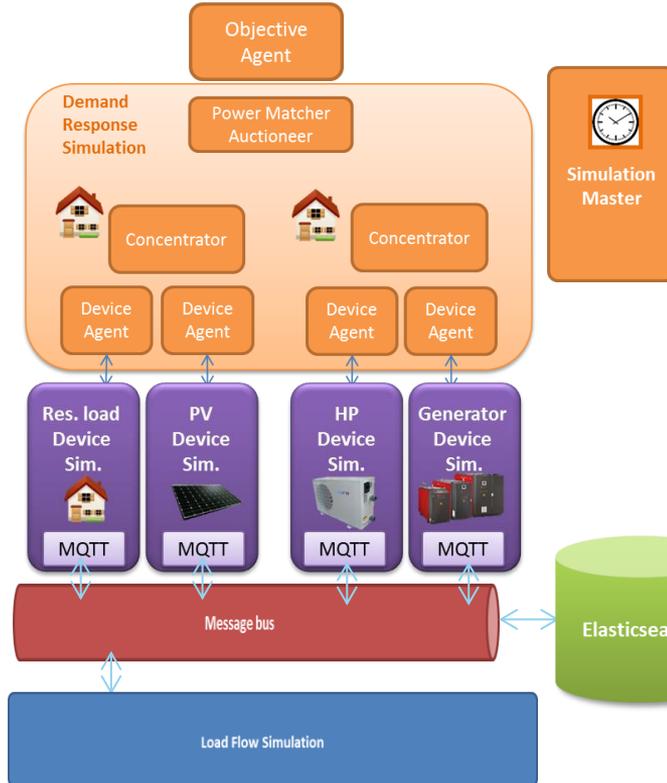
Profiles (load, price, weather, ...)



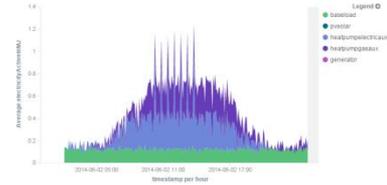
Objectives, control mechanism, period

Configurator

## Step 2: Model operation



## Step 3: Result analysis and visualization



## Example test case

The following example further amplifies the characteristics and possibilities of the ITSF

Given a specific scenario (energy mix, penetration of devices and distributed generation, etc.) and a specific MV grid topology, determine for the year 2020:

1. Are network constraints to be expected in 2020, when no Demand Response is applied in this MV grid (and connected LV grids)?
2. If not, are network constraints expected when a commercial aggregator will apply Demand Response, with the main purpose of actively participating in system balancing?
3. If so, can network constraints be removed by an aggregator, applying demand response for grid support?

Besides testing and certification services, the ITSF also offers a realistic, large scale simulation environment that can be used for scenario planning.

# ITSF for Future Energy Systems: Making smart grids safer

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# Simulation process flow

## Step 1: Scenario configuration

- Select simulation objectives [ "congestion management", "self healing"]
- Define intelligent control mechanism ["powermatcher"]
- Define control mechanism strategy ("propositions")
- Select target residential market [ "average NL SMALL", "energie neutrale wijk", etc.]
- Select electric infrastructure topology and design standard
- Select years to be evaluated [ 2015,...,2050]
- select climate test consisting of one/ multiple Business as Usual (BAU) and extreme days
- Select smart technology under test [solar PV, air source heat pump, etc.]
- Select adoption curves technology under test ["normal", "high"]
- Select adoption scenarios for the other non-smart technologies [solar PV, air source heat pump, etc.] to define [ "normal", "extreme "] background scenarios.

## Step 2: Model operation

- Run simulation for [technology under test X] with [ selected adoption curve] in the [ selected residential market] for [ selected year] in the variant[ intelligent control on] and [ intelligent control off] with the energy infrastructure optimization focus on [ selected E-network optimization focus]

## Step 3: Result analysis

- Create for each run the spectra of [*available capacity*] and KPI's [ market efficiency+ technology conversion efficiency, etc.]
- Expert interprets the differences between the spectra and KPI's of the individual runs.