4th International Workshop on
Grid Simulator Testing of Energy System
and Wind Turbine Powertrains
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Overview of Smart System Research Facility (FREA-G) Fukushima Renewable Energy Institute, AIST

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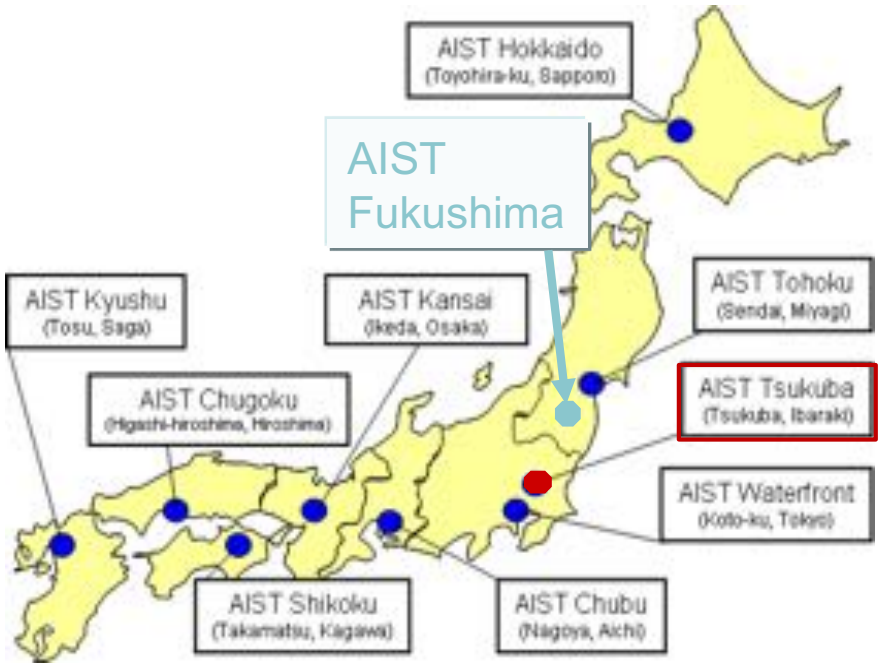
National Institute of
Advanced Industrial Science and Technology (AIST)

AIST - Overview

- AIST is a national research institute with
  - 2300 scientists, 100B yen/ year
  - 10 sites all over Japan
  - work with industry, universities, internationally

Research Domain	Research Office
	

FREA: Fukushima Renewable Energy Institute, AIST

Missions

- International R&D base for renewable energy
- New industry promotion in damaged area

Location

Koriyama, Fukushima

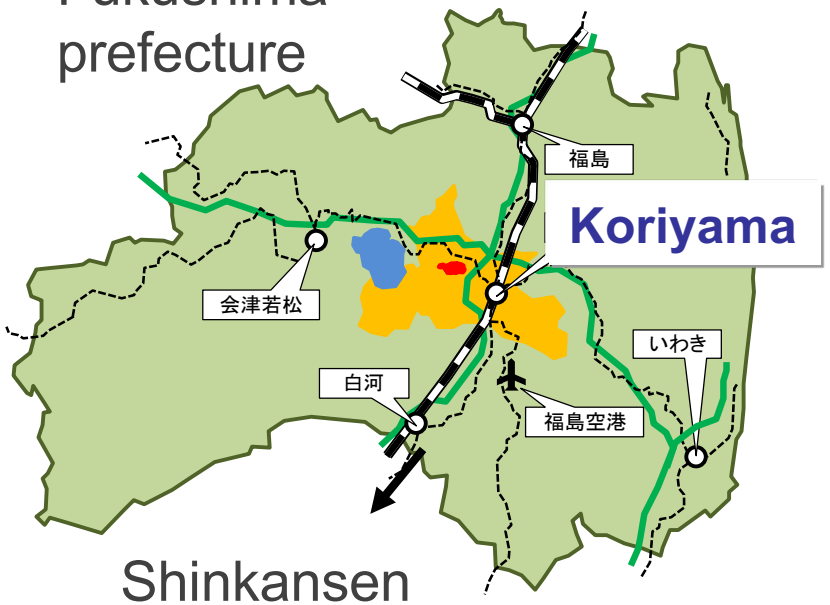
Schedule

2013,Oct. organization founded
2014, Apr. open in Koriyama

Budget

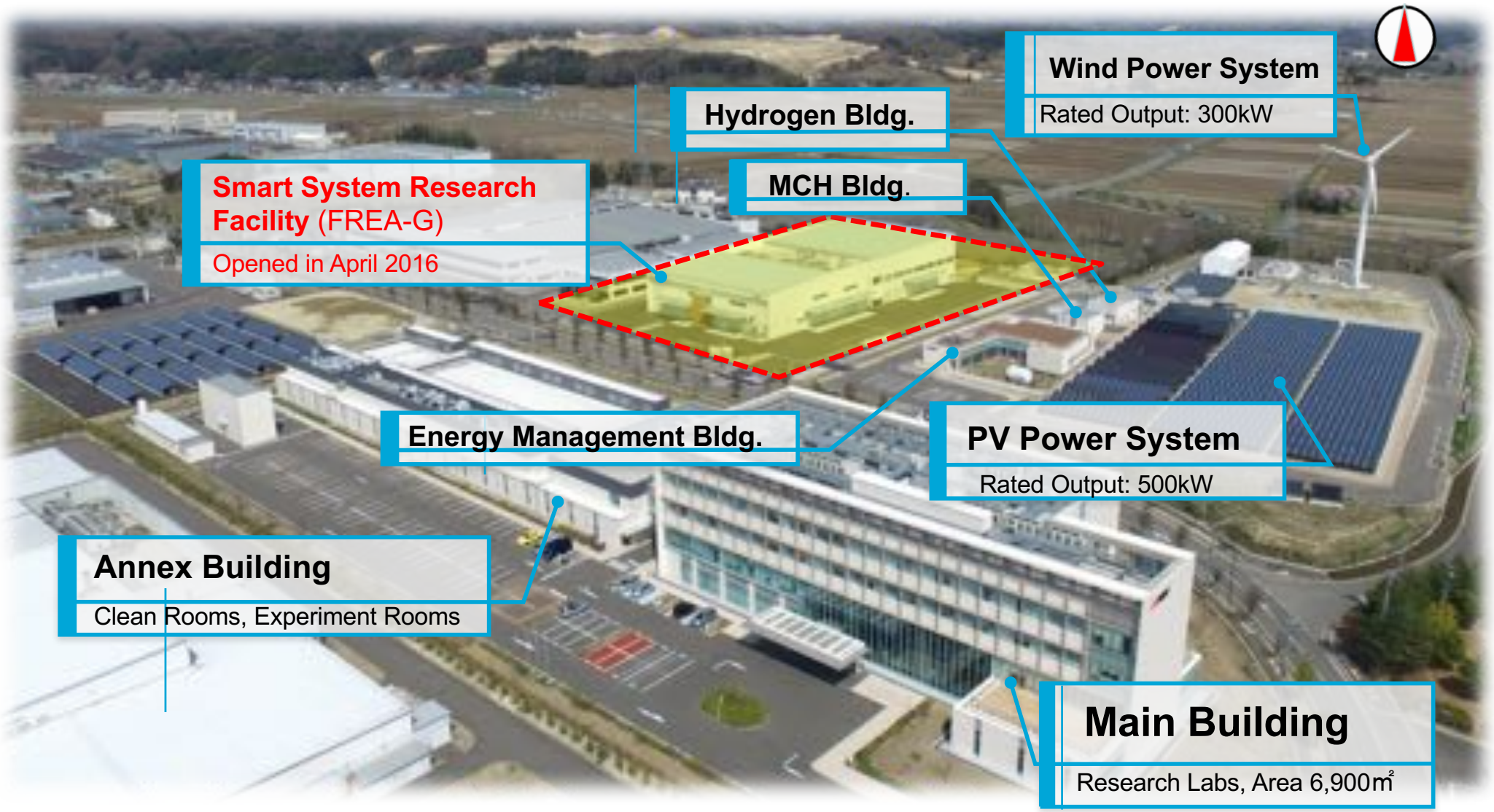
10 billion yen for start up
(land, buildings, equipment)
3 billion yen/y, 400 people and more

Fukushima prefecture



Shinkansen
80min. to Tokyo

Total View of FREA



Our Smart System R&D Test Platform called FREA-G

- Open in April 2016 at FREA
- Operating by AIST as a user's facility
- Subsidy from METI: 73 million U.S. dollars
- Maximum Test Capabilities
  - EUTs (DERs): Up to 3 MW
  - DC power source (PV Simulator): 3.3 MW
  - AC power source (Grid Simulator): 5.0 MVA
  - Environmental chamber: -40 to 85 degree in C
  - EMC testing room

FREA-G Concept

- Substantially expand the aforementioned FREA facility to build the world's most advanced test facility.

A. Grid Connection Test Bed

- Conduct required tests to secure power quality for the grid connection of distributed generations.
- Conduct various PCS tests (anti-islanding test, FRT test, etc.)
- Maximum capacity of AC simulator: 5MVA.
- Maximum capacity of EUT: 3MW.

B. Safety Test Bed

- Conduct high-temperature acceleration and heat cycle tests with PCS where real environment is simulated to evaluate long-term reliability, and also safety-related tests including surge voltage test.

C. EMC Test Bed

- Conduct tests to measure electromagnetic radiation from PCS and to check if PCS's functions and behavior would be inhibited by external electromagnetic wave.

D. System Performance Test Bed

- Evaluate different capabilities (e.g. automatic control function to maximize output depending on the weather) of distributed generations (PV, batteries, etc.) and PCS as one single system.

Achievements in the first half-year

- The first tests were successfully completed in all test rooms (grid-connection test, environment test and EMC test).
- Cooperation with JET (Japan Electrical Safety & Environment Technology Laboratories) has been efficient to meet various test requirements from manufactures.
- Data for certification tests were provided to a few certification bodies to get their certification.
  - *e.g. Thai PEA (Provincial Electricity Authority) added one Japanese PV inverter in their certified inverter list based on our data in June 2016.*

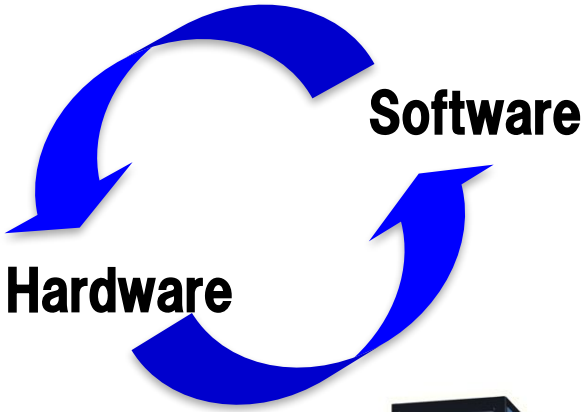
①Hard Testing ②Interoperability Testing ③System Proofing

FREA-G Test bed

・Single EUT testing

FREA-G with HILs

・EUT test with HILs

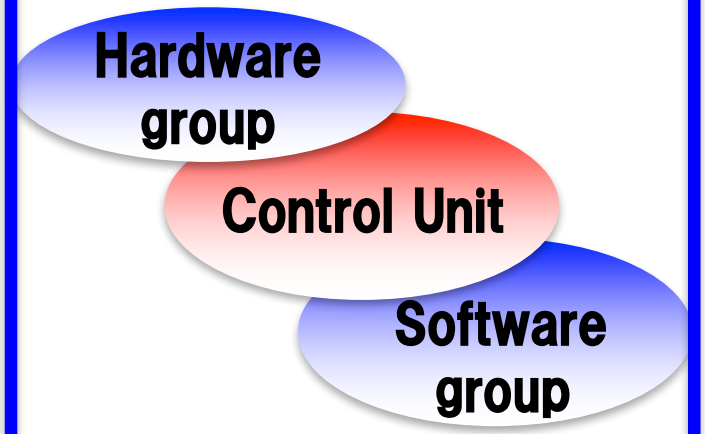


Flexibility

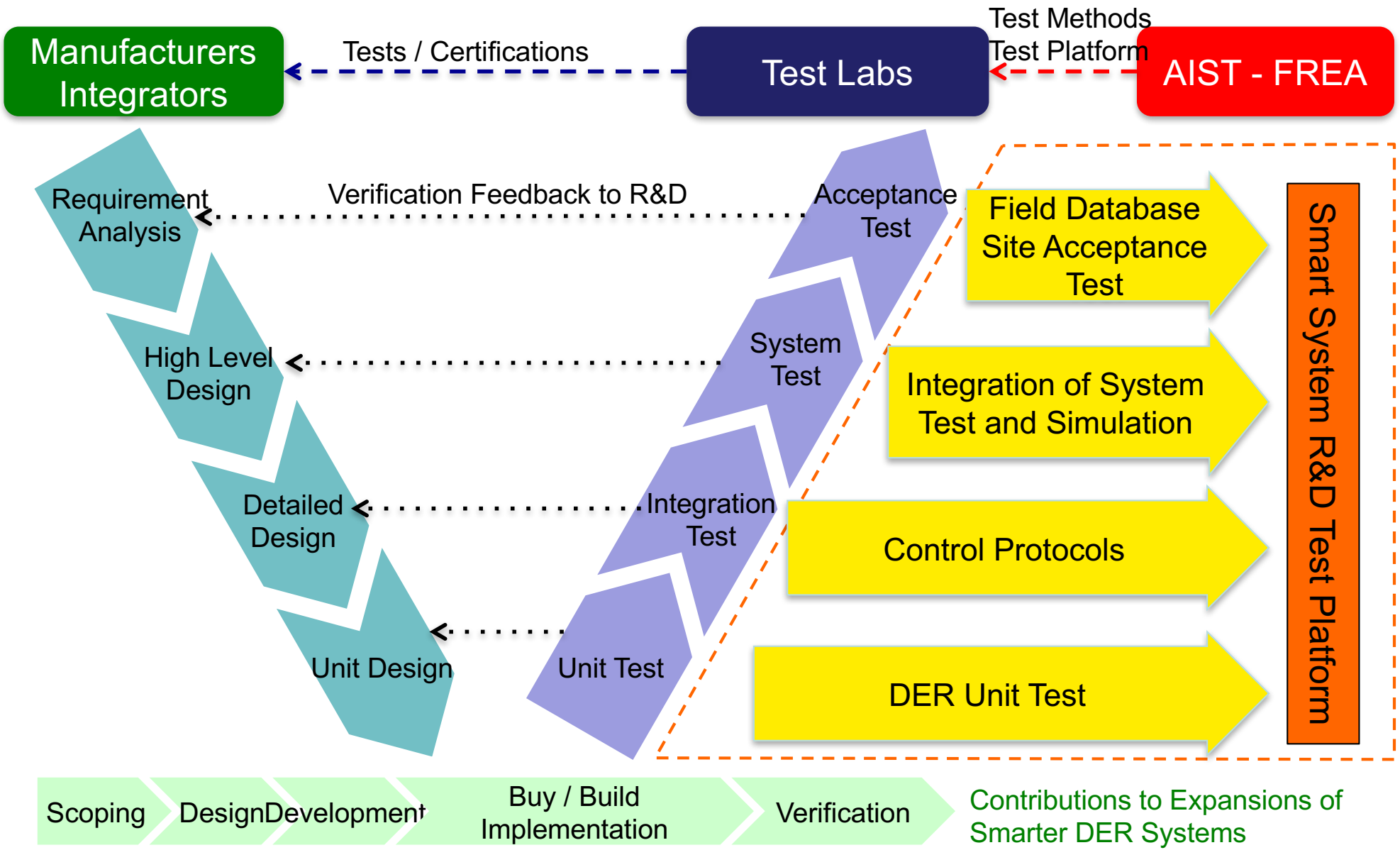
Real Time Digital Simulator

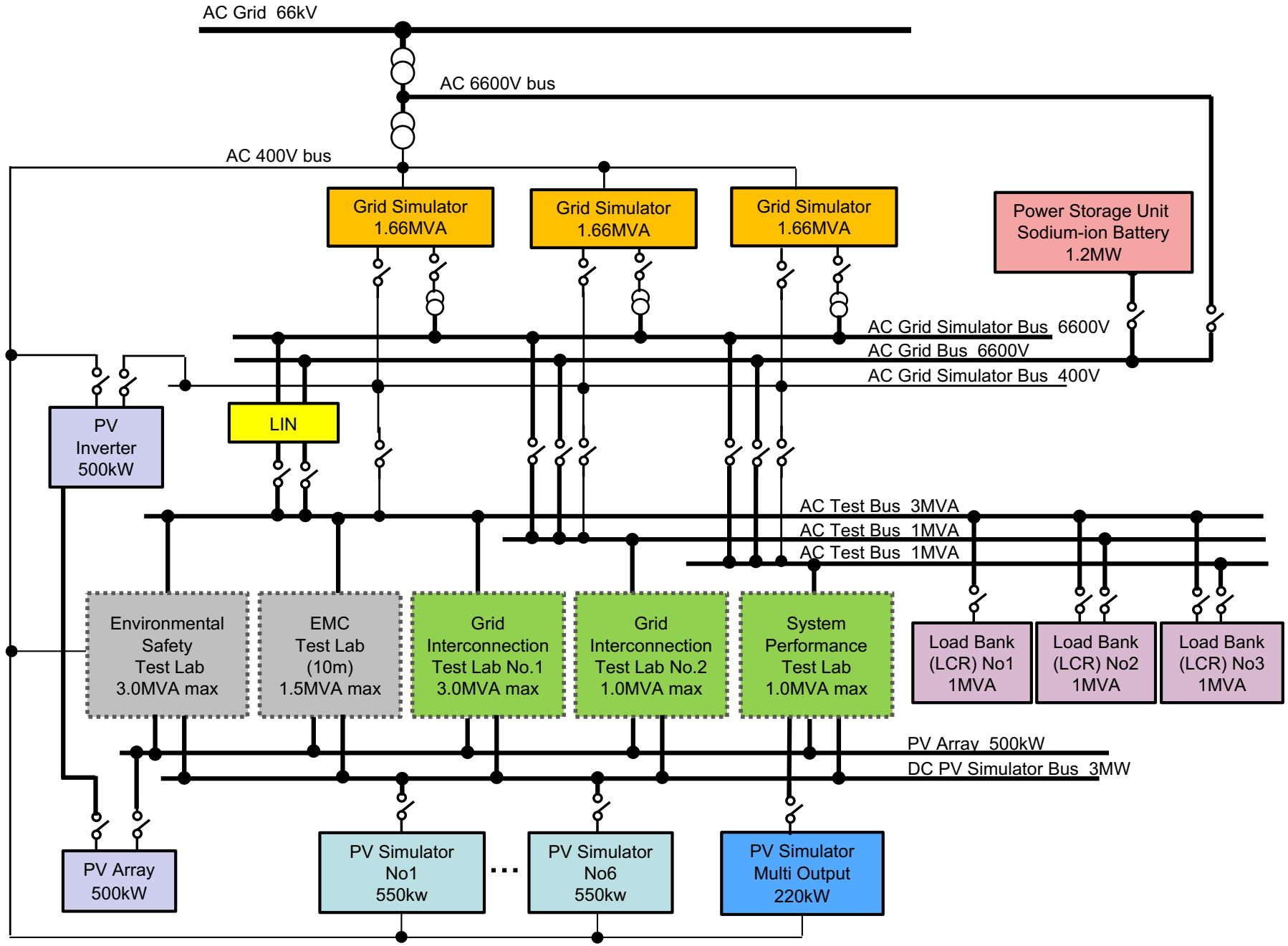
System Validation Field

・DER testing platform



Smart System R&D Test Platform




AC Grid 66kV
AC 6600V bus
AC 400V bus
Grid Simulator 1.66MVA
Grid Simulator 1.66MVA
Grid Simulator 1.66MVA
Power Storage Unit Sodium-ion Battery 1.2MW
AC Grid Simulator Bus 6600V
AC Grid Bus 6600V
AC Grid Simulator Bus 400V
PV Inverter 500kW
LIN
AC Test Bus 3MVA
AC Test Bus 1MVA
AC Test Bus 1MVA
Environmental Safety Test Lab 3.0MVA max
EMC Test Lab (10m) 1.5MVA max
Grid Interconnection Test Lab No.1 3.0MVA max
Grid Interconnection Test Lab No.2 1.0MVA max
System Performance Test Lab 1.0MVA max
Load Bank (LCR) No1 1MVA
Load Bank (LCR) No2 1MVA
Load Bank (LCR) No3 1MVA
PV Array 500kW
DC PV Simulator Bus 3MW
PV Array 500kW
PV Simulator No1 550kw
PV Simulator No6 550kw
PV Simulator Multi Output 220kW

Achievements of FREA-G

- Since FREA-G was open in April 2016, following 12 projects have already been carried out (some of them are still in progress)
- FREA-G has capabilities of testing for certifications in various regions such as Asia, U.S. and Europe and various standards such as UL, VDE, IEC and CEC.

Achievements of FREA-G (Since April this year)

Objective	Standard	Testing item
Test for Thailand certification	IEC	Anti-islanding ; tested by JET
	IEC	Low Voltage Ride Through (LVRT) ; tested by JET
1,500V PV inverter test for U.S. certification	UL1741	Anti-islanding
	UL1741	Low Voltage Ride Through (LVRT)
	CEC	CEC efficiency
1,500V PV inverter test for Europe certification (TBD)	VDE	Low Voltage Ride Through (LVRT)
	VDE	Anti-islanding
Developing test	-	Low temperature operation test
	-	Reliability test (damp heat test)
Proposal for new standard	IEC NP	Energy efficiency evaluation for grid connected PV inverter
	IEC NP	Basic requirement of AC simulator for PV inverter testing
	IEC NP	Basic requirement of DC simulator for PV inverter testing

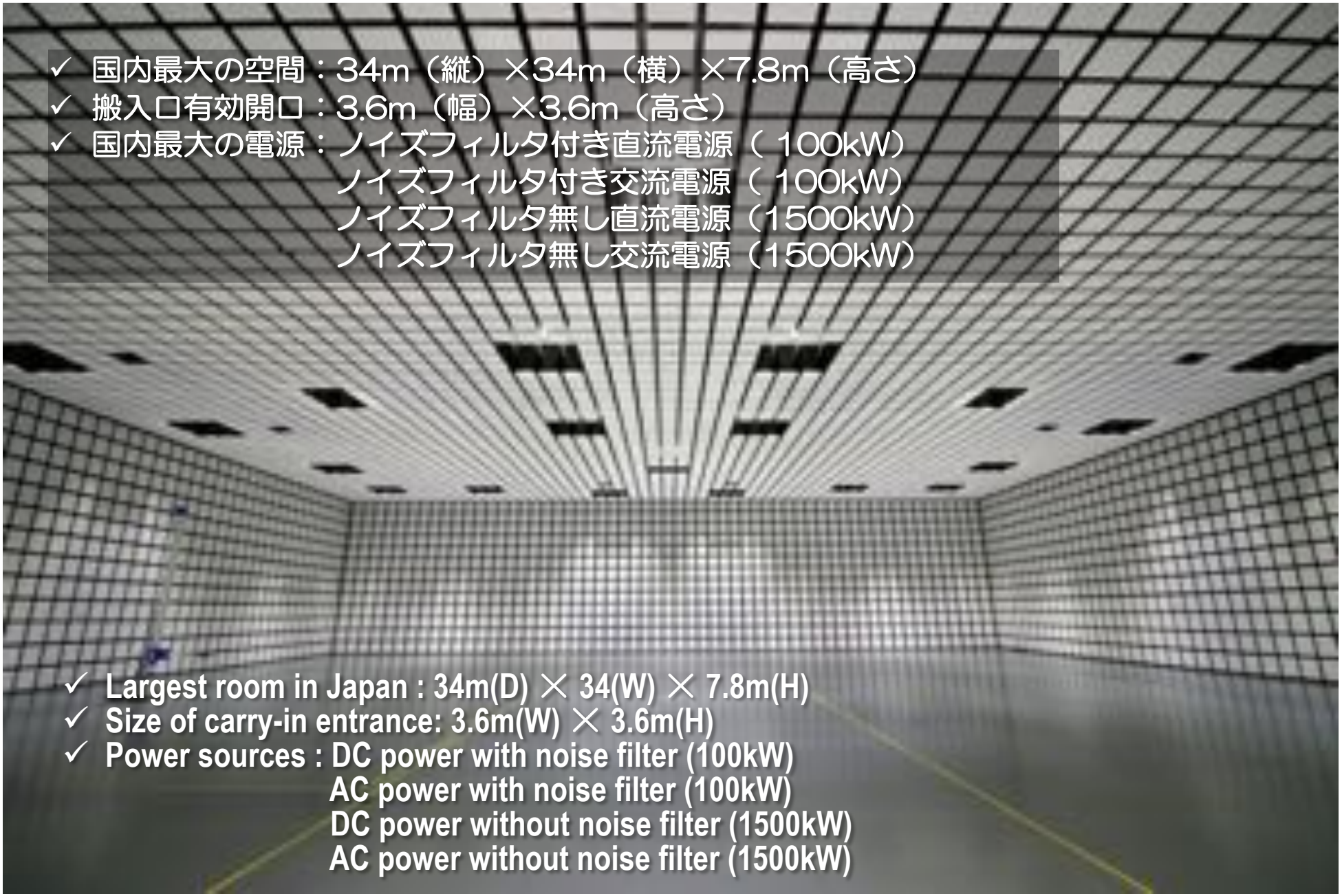

研究本館
Main Building
実験別棟
Annex Building
スマートシステム研究棟
Smart System Research Facility
実証フィールド
Demonstration Field


電波暗室
Radiowave Darkroom
系統連系
試験室（S）
Grid Connection
Test Lab.S
環境試験室
Environmental
Test Lab.
系統連系
試験室（L）
Grid Connection
Test Lab.L
系統連系
試験室（M）
Grid Connection
Test Lab.M
研究室
Research Lab.
蓄電池試験体の置き場
Battery Yard


見学窓
Viewing Window
交流電源接続盤（低圧）
AC Power Connecting Board
(Low Voltage)
模擬配電線路
Simulation Power Distribution Line
直流電源接続盤
DC Power Connecting Board
計測システム
SCADA & DAQ


見学窓
Viewing Window
交流電源接続盤（高圧）
AC Power Connecting Board
(High Voltage)
交流電源接続盤（低圧）
AC Power Connecting Board
(Low Voltage)
計測システム
SCADA & DAQ
直流電源接続盤
DC Power Connecting Board


交流電源接続盤（低圧）
AC Power Connecting Board
(Low Voltage)
交流電源接続盤（高圧）
AC Power Connecting Board
(High Voltage)
太陽電池模擬電源
（中小容量用）
Multi Output PV
Simulator
直流電源接続盤
DC Power Connecting Board
見学窓
Viewing Window


✓ 国内最大の空間：34m（縦）×34m（横）×7.8m（高さ）
✓ 搬入口有効開口：3.6m（幅）×3.6m（高さ）
✓ 国内最大の電源：ノイズフィルタ付き直流電源（ 100kW）
ノイズフィルタ付き交流電源（ 100kW）
ノイズフィルタ無し直流電源（1500kW）
ノイズフィルタ無し交流電源（1500kW）
✓ Largest room in Japan : 34m(D) × 34(W) × 7.8m(H)
✓ Size of carry-in entrance: 3.6m(W) × 3.6m(H)
✓ Power sources : DC power with noise filter (100kW)
AC power with noise filter (100kW)
DC power without noise filter (1500kW)
AC power without noise filter (1500kW)

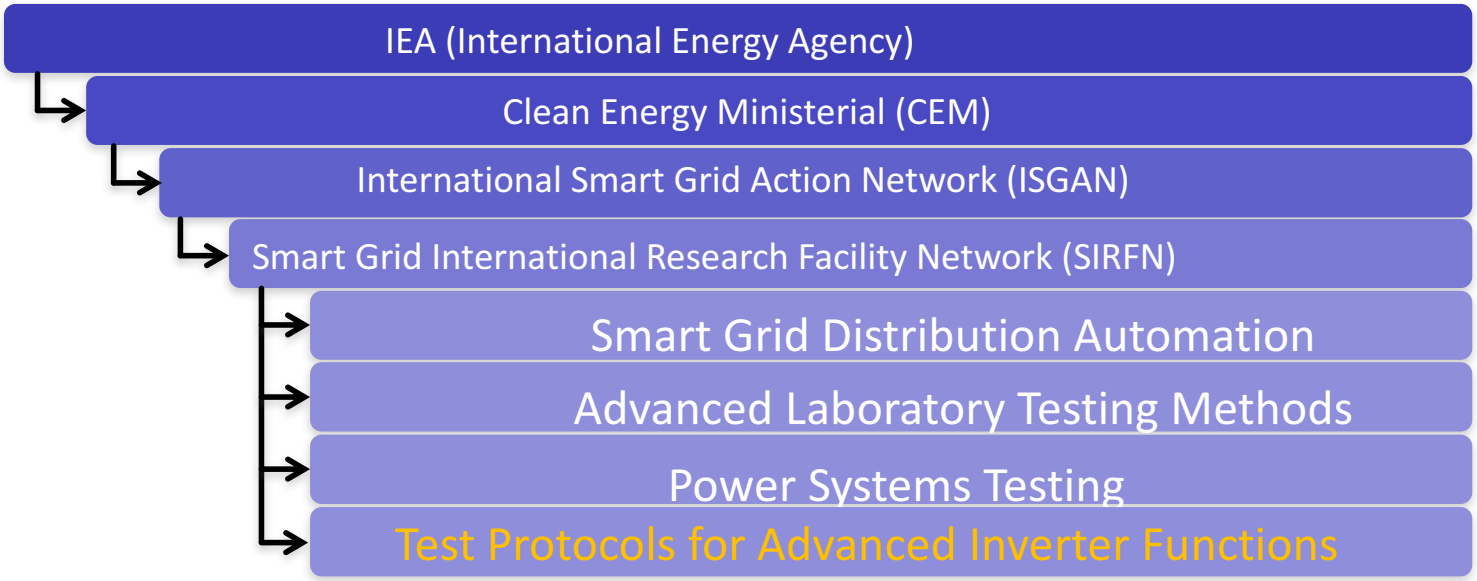

✓ 大空間：5.5m（縦）×12.5m（横）×4.6m（高さ）
✓ 温度範囲（-４０～＋８５℃）
✓ 湿度範囲（３０～９０%RH）
✓ 高性能（高速な室内温度変化）
✓ 最大電力（３メガワット）
✓ 搬入口有効開口：6.5m（幅）×4.1m（高さ）
✓ 砂漠地、高温湿潤地、極寒地での使用を想定した温湿度サイクル試験等が可能
✓ Large space : 5.5m (D)×12.5m (W)×4.6m (H)
✓ Temperature range (−40 ~ +85°C)
✓ Humidity range (30 ~ 90%RH)
✓ High performance (High ramp rate)
✓ Maximum power (3 megawatt)
✓ Size of carry-in entrance: 6.5m (W)×4.1m (H)
✓ Variety of temperature and humidity cycle test for desert, tropical or cold area


✓ 大出力（最大５メガワット）
✓ 高電圧（４００ボルト／６０００ボルト）
✓ 高性能（バックツーバック電源）
✓ 世界中の電力システムの周波数、電圧を模擬可能
✓ 事故時運転継続（FRT）機能の試験に利用
単機出力：１６７０キロワット
合計３台での並列運転が可能
✓ High power (5 megawatt at the maximum)
✓ High voltage (400 volt / 6000 volt)
✓ High performance (back-to-back power sources)
✓ AC power source to simulate frequency and voltage of electric power systems in the world
✓ Use for Fault Ride Through (FRT) test
Single Unit: 1670 kilowatt
Possible to run 3 units in parallel


単機出力：５５０キロワット
１０００ボルト
合計６台で直並列回路を構成
✓ 大出力（最大３．３メガワット）
✓ 高電圧（最大２０００ボルト）
✓ 結晶シリコン、薄膜シリコンなどの様々な太陽電池の発電状態を模擬
✓ 日射変動による出力変動の模擬も可能
Single power : 550 kilowatt
1000 volt
Configure a series-parallel circuit with 6 units
✓ High power (3.3 megawatt at the maximum)
✓ High voltage (2000 volt at the maximum)
✓ DC power source to simulate PV array systems, which is crystalline silicon, thin film silicon, etc.
✓ Possible to simulate time-series of power output according to the fluctuation of solar irradiance


実験用模擬負荷
RLC Load Simulator
防音壁
sound barrier
✓ 大型（３メガワット）
✓ 太陽光発電用パワーコンディショナの単独運転防止試験等に利用
✓ Large scale (3 megawatt)
✓ Use for anti-islanding test for PCSs of Solar photovoltaic system

SIRFN Smart Grid Collaboration



SIRFN - A coordinated network of smart grid research facilities from:

- **Primary goal**: Develop and demonstrate a consensus-based interoperability certification standard for advanced Distributed Energy Resources (DERs).
  - Design and compare advanced interoperability test-beds.
  - Perform round-robin testing of advanced DER.
  - Compare test results, communications methods, and automation procedures.
  - Gradually improve draft test procedures for advanced DER with the goal of becoming an internationally-accepted standard.

Execution of draft protocol to ESS: SIRFN Testing Laboratories

Team members at AIT Smart Electricity Systems and Technologies (SmartEST) PV inverter test laboratory

Team Members at RSE Distributed Energy Resource (DER) Test Facility

Team members at FREA Smart DER Research Facility

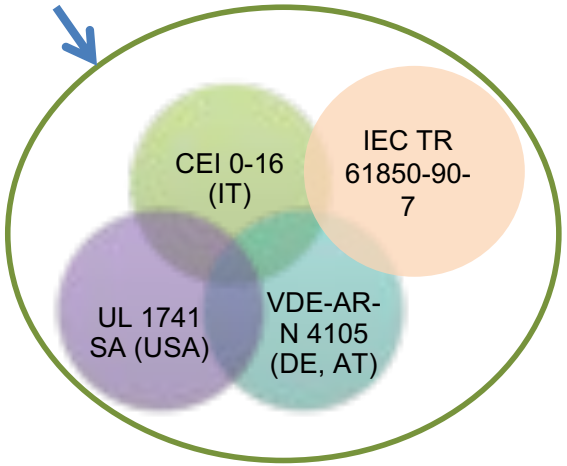
Team Members at Sandia's Distributed Energy Technology Lab (DETL)

BESS Test Protocol Lab Requirements

The four laboratories in the Smart Grid International Research Facility Network (SIRFN) have been formulating evaluation and certification protocol for BESS interoperability and functionality.

- Tested interoperability functions defined in IEC TR 61850-90-7
  - Commanded Power Factor（INV3）
  - Request Active Power（INV4）
  - Var-Priority Volt-Var（VV12）
  - Request Reactive Power（VV13）
  - Frequency support by Active Power (FW)

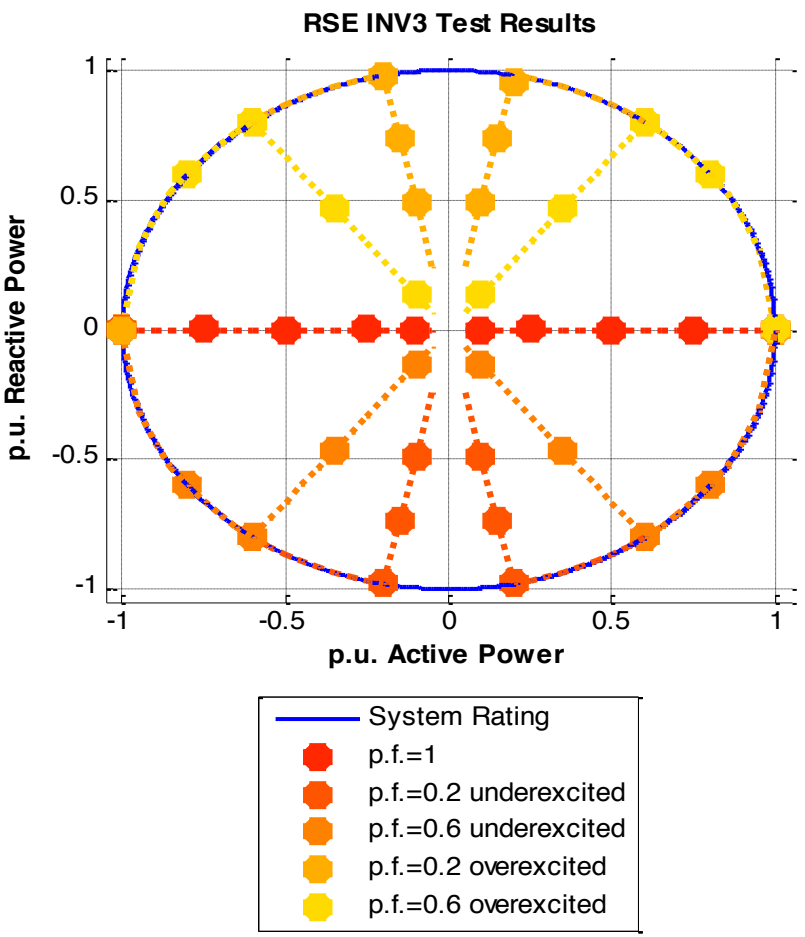
SIRFN ESS Protocol Requirements

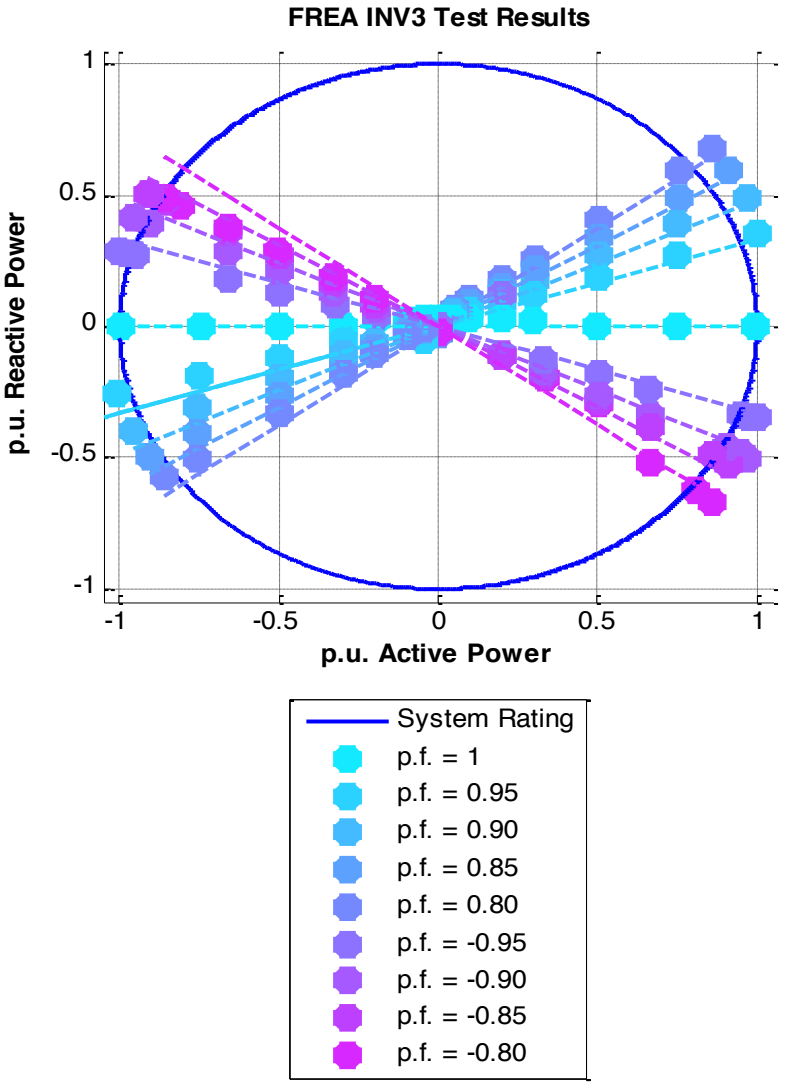


Be harmonized and inclusive with existing international standards, International requirements and National Grid Codes

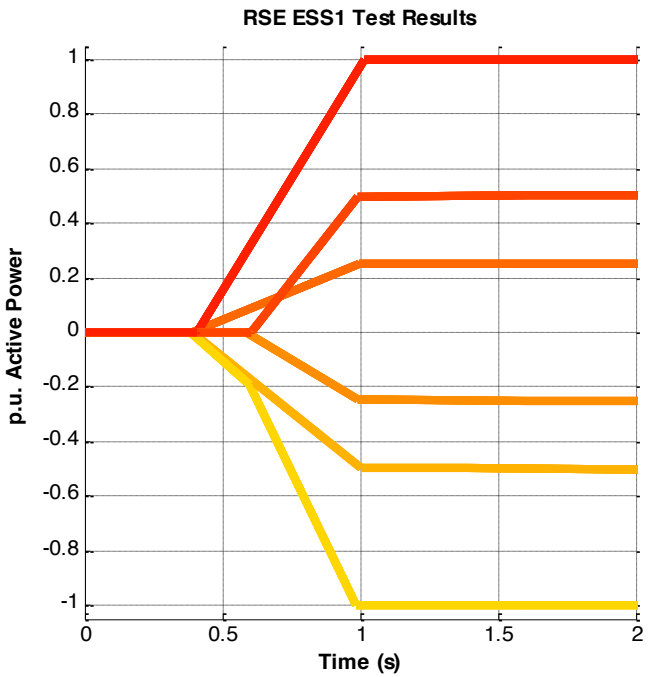
BESS interoperability test protocols Published from IEA ISGAN (http://www.iea-isgan.org)

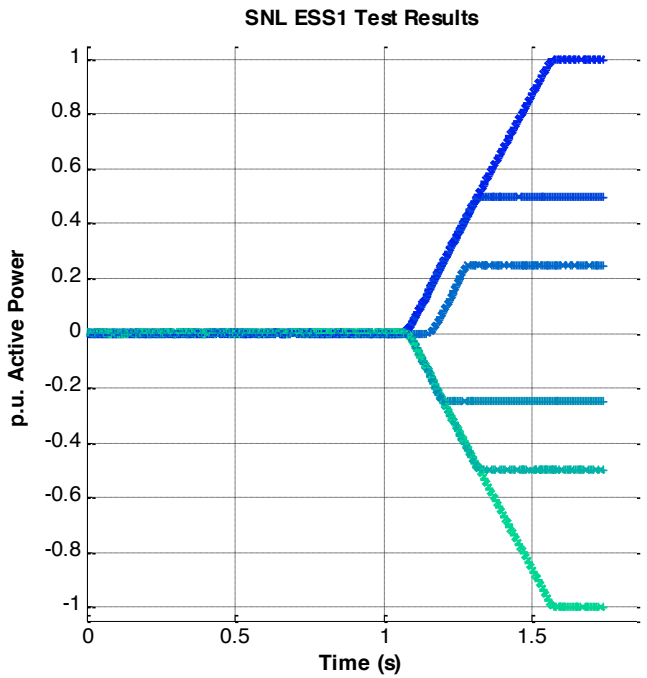
Review Data and Refine Protocols: Commanded Power Factor

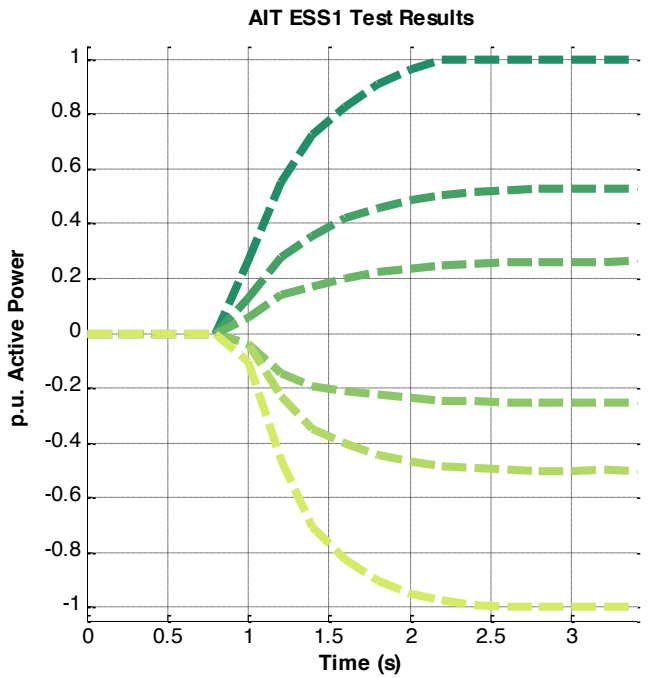




Review Data and Refine Protocols: Commanded Active Power







Activity and Capability of FREA-G in 2016

- Open in April 2016 and conduct total 20 tests in last year
- We keep upgrade this facility to adapt advanced functionality such as advanced inverter, HIL testing etc.

Capability

- Up to 3MW EUT can test at FREA-G
- First 2.7MW/1500V EUT was tested in 2016 Dec.
- Capable to test Large capacity EUT for Interconnection test, Reliability test and EMC test

International

- Capability to test IEC standard and others
- First interconnect test for Thailand was tested and accepted by PEA (Thailand)
- JET accelerate international certification by using our facility

Domestic

- JET start inverter certification for Japanese Grid code at FREA-G
- Seven units has been tested by this scheme

Other

- PV system EMS testing was conducted at FREA-G
- Cutting edge new FACT equipment was tested (EMC, Reliability and Performance)

Thank you!

Contact to:
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