

## FutureEnergy project

This is the first newsletter of the EMPIR project 'Metrology for future energy transmission (FutureEnergy)'. The three-year project started in June 2020, and it is building on the EMPIR projects 'Metrology for the electric power industry (14IND08 ElPow)', 'Techniques for ultra-high voltage and very fast transients (15NRM02 UHV)' and the EMRP project 'HVDC future power grids (07ENG HVDC)'.

Driven by the need for increased efficiency, transmission grid voltages have been pushed to ultra-high voltages (UHV), beyond 1000 kV. This project will realise metrology solutions for grid component testing and condition monitoring required for successful implementation of future UHV transmission grids.

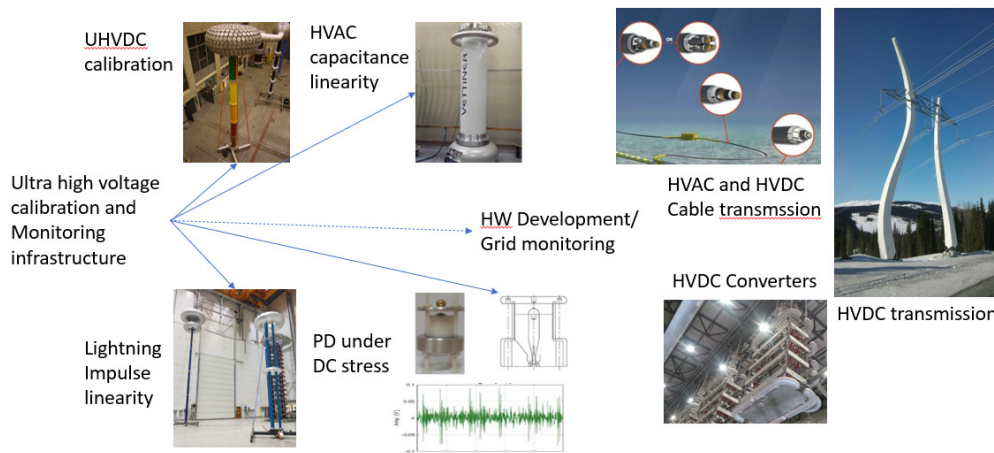
Society's increasing demand for electrical energy, along with the increased integration of remote renewable generation has driven transmission levels to ever higher voltages in order to maintain (or improve) grid efficiency. Consequently, high voltage testing and monitoring beyond voltage levels covered by presently available metrology infrastructures are needed to secure availability and quality of supply.

Calibration services for UHVDC are not available above 1000 kV. There is a need to extend the calibration capabilities for voltage instrument transformers up to 1200 kV and for factory component testing capabilities up to 2000 kV.

The overall aim of the project is to provide traceability for metrology in testing and calibration of components for future electricity grids, and to provide improved means for HVDC grid condition monitoring. The specific objectives are:

- extend the traceable calibration of Ultra-High Voltage Direct Current (UHVDC) up to at least 1600 kV
- extend and research methods for lightning impulse voltage calibration for testing of UHV equipment
- develop a new method(s) for linearity determination of HV capacitors
- develop and demonstrate implementation of partial discharge (PD) measurements under d.c. stress
- facilitate the take up of the technology and measurement infrastructure developed in the project

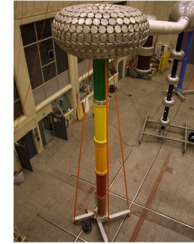
### Project infrastructure



## Research highlights

### *UHVDC traceability*

Building on the d.c. voltage traceability obtained in EMRP project ENG07 HVDC for on-site calibration up to 1000 kV, capability will be enhanced from 20  $\mu\text{V/V}$  at 1000 kV to 1200 kV with a 40  $\mu\text{V/V}$  uncertainty for calibration of reference measurement systems used for calibration of d.c. voltage instrument transformers. A lower-echelon measuring system will be constructed with capability up to 1600 kV (possibly 2000 kV), which will satisfy the need for calibration of UHVDC measuring systems, with a target measurement uncertainty of 200  $\mu\text{V/V}$ .



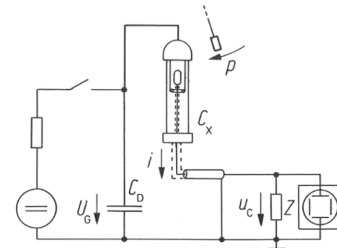
### *Lightning impulse linearity extension*



Typically, NMIs can provide traceability for lightning impulse (LI) voltage measurement systems up to 500 - 700 kV. For calibration of large LI measurement systems in industrial laboratories which are typically used up to 3000 kV, linear extension is needed to support approved measurements up to 3500 kV. Scientific proof is lacking to confirm this extension's validity above 2000 kV. Typical errors of 1 % for test voltage values were observed at 2700 kV in EMPIR project 14IND08 EIPow, but more than 3 % errors for experiments above 3000 kV are reported. Errors in the determination of the rise time of the impulse are even more significant. This project will extend metrology beyond the 2000 kV limit by developing and validating methods for linear extension up to 3500 kV, determining measurement uncertainties, and finding solutions for the large front time errors.

### *Voltage linearity of UHVAC references*

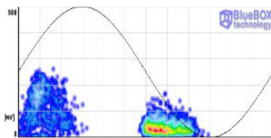
Voltage traceability for a.c. is typically provided by using inductive voltage transformers or capacitive voltage dividers with an uncertainty of around 50  $\mu\text{V/V}$  at 200 kV, and 500  $\mu\text{V/V}$  at 800 kV. Higher uncertainty at higher voltage levels is due to the voltage non-linearity in compressed gas capacitors and increasing intensity of corona. Existing voltage linearity determination methods (Latzel et al) have uncertainties much lower than 10  $\mu\text{V/V}$  but are applicable to compressed gas capacitors only and rely on mechanical design data.



This project will extend beyond the state of the art by developing new effective methods (applicable to any reference capacitor) for on-site determination of linearity errors in HV capacitors with a target uncertainty of 80  $\mu\text{V/V}$  at 800 kV.

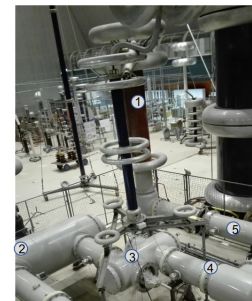
### *HVDC grid condition monitoring*

HVDC systems have recently been modelled, and a PD waveform generator developed, to study insulation under d.c. stress in EMPIR project 15NRM02 UHV. Low-level PD calibration services below 1 pC have also been developed. However, neither specific methods, nor characterisation setups for GIS, nor any PD calibrators to recognise or reproduce PD patterns applicable to measurements under d.c. stress, currently exist. Going beyond the state of the art, a calibration procedure will be developed to qualify PD analysers working in the frequency



range between 1 MHz and 30 MHz, emphasising the system's ability to discriminate between PD signals and representative noises in cables and converters.

This project will extend PD charge evaluation in HVDC GIS in the 30 – 300 MHz range using a specialised high voltage GIS setup up to 100 kV with reference test cells.



TU/eft GIS: 1. bushing, 2. CB, 3. switch, 4. spacer, 5. enclosure

## Contact and further information

The consortium consists of 7 National Metrology Institutes, 3 universities, and 2 companies and thus have measurement capabilities traceable to national standards, sites to host the measurements facilities and test their performance and companies to develop and exploit their technology.





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**Project homepage:** <https://www.ptb.de/empir2020/futureenergy/home/>

**To register as a project stakeholder,** contact Alf-Peter Elg, RISE (alf.elg@ri.se).

## Project partners:

	RISE	Research Institutes of Sweden	Sweden	NATIONAL METROLOGY INSTITUTES
	FFII	Fundación para el Fomento de la Innovación Industrial	Spain	
	LNE	Laboratoire national de métrologie et d'essais	France	
	PTB	Physikalisch-Technische Bundesanstalt	Germany	
	TUBITAK	Türkiye Bilimsel ve Teknolojik Arastırma Kurumu	Turkey	
	VSL	VSL B.V.	Netherlands	
	VTT	Teknologiaan tutkimuskeskus VTT Oy	Finland	ACADEMIA
	TAU	Tampereen korkeakoulusäätiö sr	Finland	
	TU Delft	Technische Universiteit Delft	Netherlands	
	UPM	Universidad Politécnica de Madrid	Spain	INDUSTRY
	Vettiner	Appareils Vettiner	France	