The project objective is to design, build, and deploy the world's first flexible large power transformer (LPT). The prototype is a 165kV, 60/80/100MVA autotransformer with three LV ratings including 57.5kV, 69kV and 80.5kV and a leakage impedance adjustable online from 4.3% to 9.3%. A flexible transformer protection system is also developed. Anticipated results include an >99.5% efficiency; a size and weight within 120% of comparable conventional LPT; compliance with IEEE standards C57.12.00 and C57.12.90; 6 months of field-testing data demonstrating comparable performance with conventional LPT.
PRINCIPAL INVESTIGATORS
Dr. Ibrahima Ndiaye, Technology Manager, GE Research
Mr. Enrique Betancourt, Applied R&D Manager, Prolec GE

WEBSITE
https://www.ge.com/research/#
DOE PROGRAM OFFICE:  
**OE – Transformer Resilience and Advanced Components (TRAC)**

FUNDING OPPORTUNITY:  
**DE-FOA-0001876**

LOCATION:  
**Niskayuna, New York**

PROJECT TERM:  
**10/01/2019 to 05/31/2022**

PROJECT STATUS:  
**Incomplete**

AWARD AMOUNT (DOE CONTRIBUTION):  
**$2,375,922**

AWARDEE CONTRIBUTION (COST SHARE):  
**$593,981**
A flexible autotransformer that has:

- 3 configurable transmission class voltage ratings at the secondary (e.g. 161kV/138kV/115kV)
- a leakage impedance that is adjustable both online and offline in a wide range
- a leakage impedance selection independent from voltage configuration

- Used only existing and proven material
Impact/Commercialization

- Can serve a universal spare to increase the grid resiliency, reduce LPT spare inventory, and reduce US dependency on foreign suppliers.

- Increase the grid flexibility in power flow and voltage regulation and make its operation more adaptable to higher penetrations of renewable generation.

- Increase the grid reliability for severe events with control of short-circuit levels.

- NPI plans are in process at Prolec GE

IP STATUS

- US 11,087,913 Transformer system – issued
- A 3rd patent disclosure on protection is pending
Innovation Update

- Completed the design and manufacturing of a 165kV, 60MVA prototype of a flexible LPT with configurable secondary at 57.5kV, 69kV and 80.5kV and a variable impedance from 4.3% to 9.3% (at 60MVA).

- Deployed and energize on 9/3/2021 with Cooperative Energy at Columbia, MS the prototype which became the world’s 1st flexible LPT in operation.

- Deployed together with the prototype a flexible protection system that can automatically update protection settings online upon impedance change.

- Prototype is undergoing 6 months of field validation with 4 months continuous operation already accrued.
Prototype specifications

Autotransformer
60/80/100 MVA
(12/16/20 MVA External Tertiary)

Connection | BIL
--- | ---
VH | 161 kV
VX | auto 350/150
VY | D 110
3Ph | ONAN/ONAF/ONAF 60 Hz 65 °C

On-line Impedance Variation range
ZH-X = 4.2 to 9.3% @ 60 MVA

Voltage regulation (in LV line)
+/- 10% of rated voltage in 16 taps

Designed and tested according to
- IEEE C57.12.00 IEEE Std for General Requirements of Liquid-Immersed Transformers
- IEEE C57.12.90 IEEE Std Test Code for General Requirements of Liquid-Immersed Transformers
Design and commissioning of the prototype

Internal layout of the designed flexible LPT prototype

On Load Voltage Tap Changer
Flexible voltage Connection Board
Auxiliary windings multiple leads.

HV, LV and TV bushings
Impedance variation automatic tap changer.

Ztap position (MS3000)

MS3000
(remote monitoring)
Transformer cabinet
(CTs, RTDs terminals)
Impedance Tap changer
(Controller)
Cooperative Energy’s 161kV substation in Columbia, MS
Commissioning of the augmented protection relay

Development and commissioning of an augmented protection relay for the flexible LPT

Protection and monitoring system
Prototype as installed at Cooperative Energy’s 161kV substation in Columbia MS
Energization of the prototype

Highest inrush current was 437A (1.22 of full load current); Significantly lower level as compared to conventional transformers.

14MVA throughput power after closing of LV breaker
Remote monitoring system reporting all the operating conditions and health status for the 6 months validation period and beyond
Prototype loading since energization (9/3/2021). Peak load of 41MVA has been observed
The development and commissioning team, September 3\textsuperscript{rd}, 2021, Columbia MS
Acronyms

CT: Current transformer
GE: General Electric
HV: High voltage
IEEE: Institute of Electrical and Electronic Engineers
LV: Low voltage
LPT: Large power transformer
MVA: Mega volt ampere (transformer power rating unit)
PT: Potential transformer
SCADA: Supervisory control and data acquisition
Ztap: Position of the flexible impedance tap changer
THANK YOU