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# **Deploying Power Flow Control to Improve the Flexibility of Utilities Subject to Rate Freezes and Other Regulatory Restrictions**

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## Utilities are facing challenges....

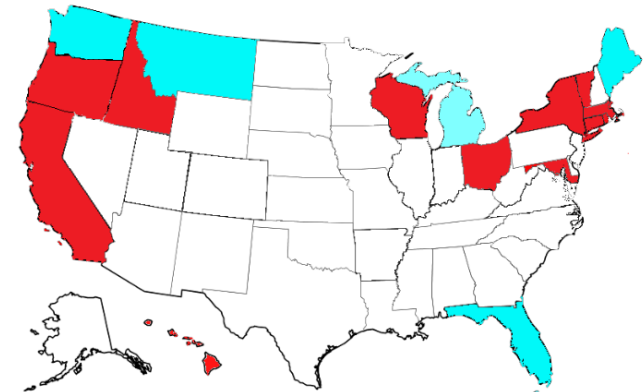
- Utilities in 19 states are subject to a combination of rate freezes, revenue decoupling, or rate indexation

## ...and uncertainties

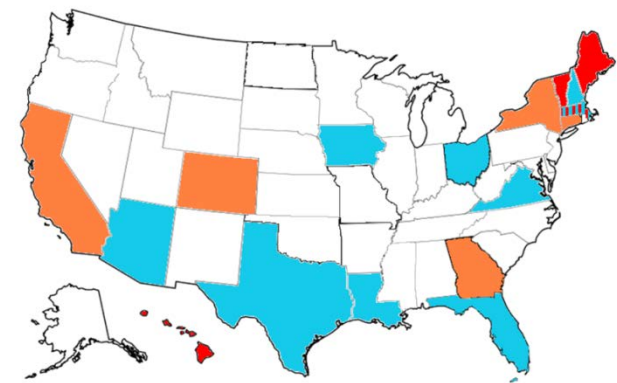
- Generation mix
- Generation location
- Load patterns
- Environmental regulations

## Study objective

- Evaluate ability of power flow control to improve the flexibility of utilities to respond to challenges and uncertainties



Current Plans
Expired Plans  
 States with Decoupling True Up Plans [1]



Indexing
Stairstep
Freeze  
 States with Recent Multiyear Rate Caps [1]

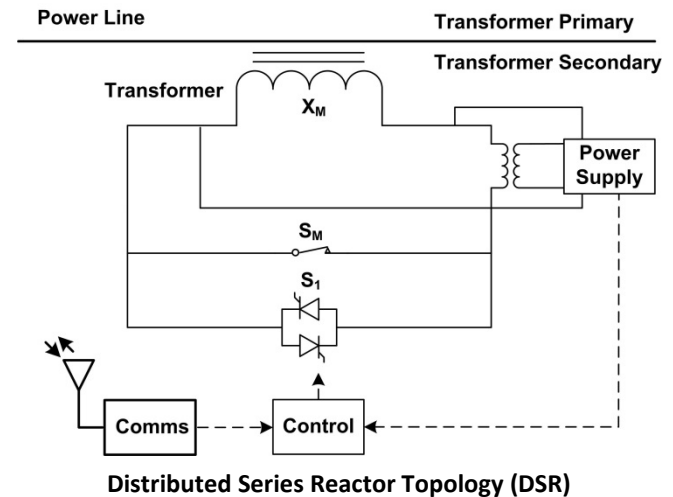
[1] EEI, Alternative Regulation for Evolving Utility Challenges: An Updated Survey, 2013

## Power flow controllers

- PST/PAR
- Air core series reactor
- FACTS (TCSC, UPFC, VFT, SSSC)
- D-FACTS (Distributed series reactor, DSSC)

## Distributed series reactor (DSR)

- Floats at line potential
- Increases line impedance in response to stored set point or external command
- Rapidly deployable and redeployable
- In use within the TVA and Southern Company footprints on operational facilities



DSR Deployed on TVA 161 kV line



## Study Overview

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### Develop alternatives

- Option #1: Business as usual (BAU)
- Option #2: Deploy DSRs

### Setup the test system

### Quantify benefits and costs

- Simulate production cost of each alternative with ACOPF

### Perform cost-benefit analysis

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## Load

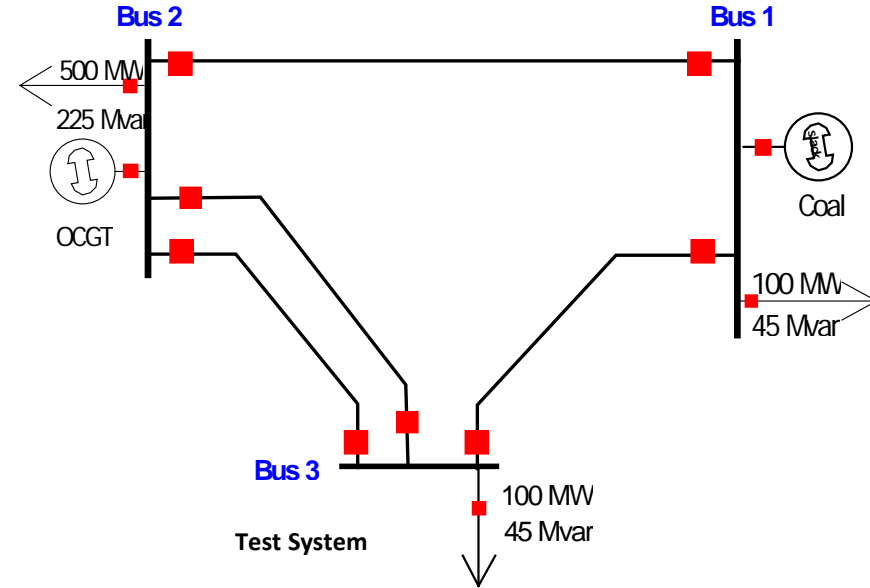
- Hourly load based on IEEE 24-bus RTS
- Analysis based on two representative weeks:
  - week with peak load hour (700 MW)
  - week with minimum load hour (237 MW)
- No load growth over study period

## Generation

- 800 MW legacy coal generator
- 600 MW OCGT gas plant
- Fuel prices: EIA projections for 2014-2023

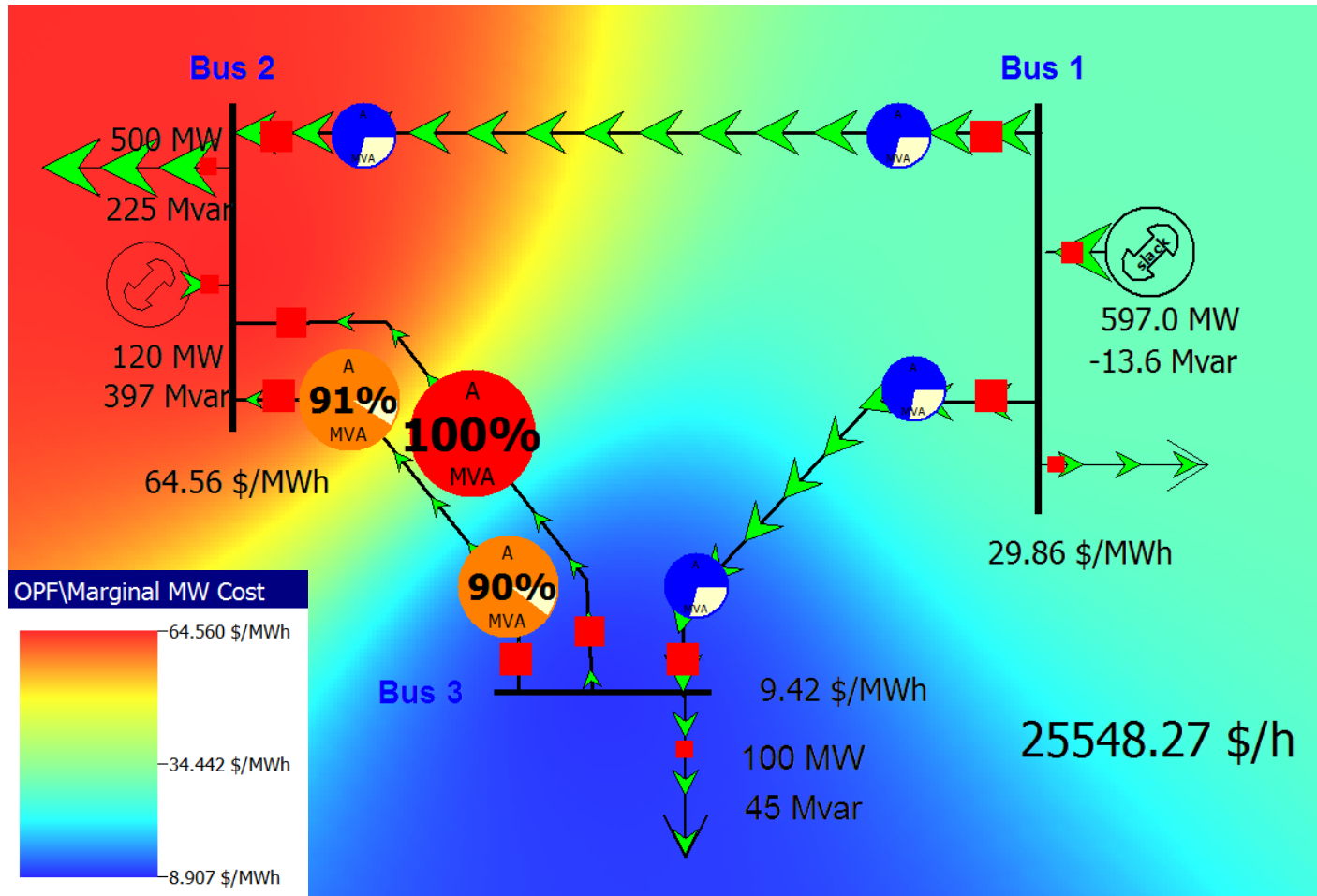
## Transmission

- 345 kV
- Reactances range from 0.045-0.05 pu
- X/R ratios range from 3.3 to 5



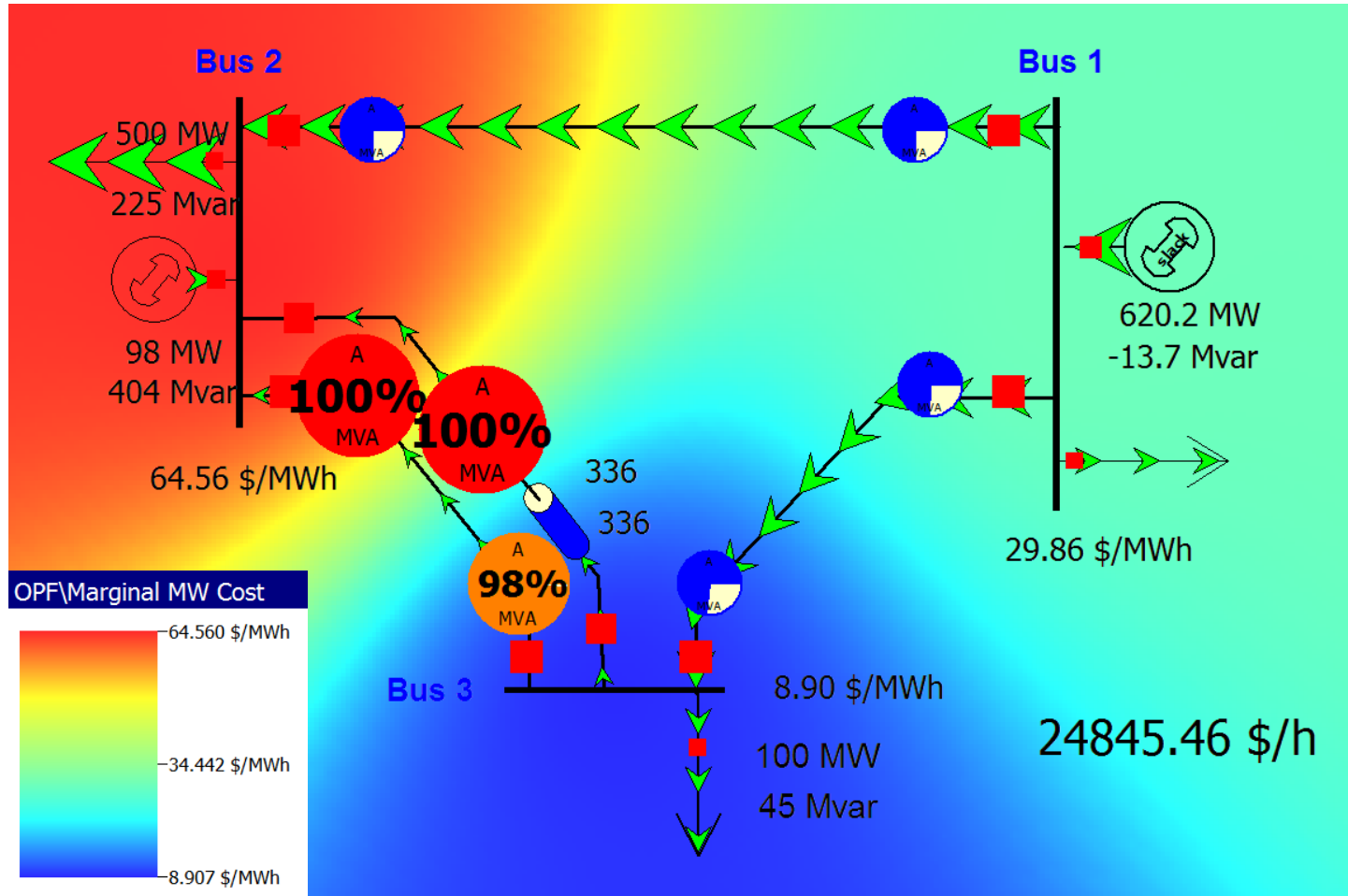
	Coal Plant	OCGT Gas Plant
Nameplate (MW)	800	600
Heat Rate (mmbtu/MWh)	10.674	10.320
Variable O&M (2010\$/MWh)	4.25	14.70
Fuel Cost (2010\$ /mmbtu)	2.40	4.83
Total Variable Cost (2010\$/mmbtu)	29.86	64.56

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# Results – DSR Deployment



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## Results – Metrics

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### Annual production cost

- BAU: \$125.12 M
- DSR deployment: \$123.68 M
- DSRs reduce the cost of energy by 1.15%

### Cost-benefit analysis

- Benefit-to-cost ratio: 3.07
- NPV positive within 4 years
- Analysis does not consider the ancillary benefits of DSRs:
  - Unit commitment savings
  - Flexibility to accommodate load and generation uncertainties
  - Improved situational awareness

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## Takeaways

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### Test system results:

- DSR deployment reduces the cost of energy
- DSR payback time is fast, mitigating the risk of stranded assets

### General takeaway:

- Power flow controllers may help manage current and pending challenges

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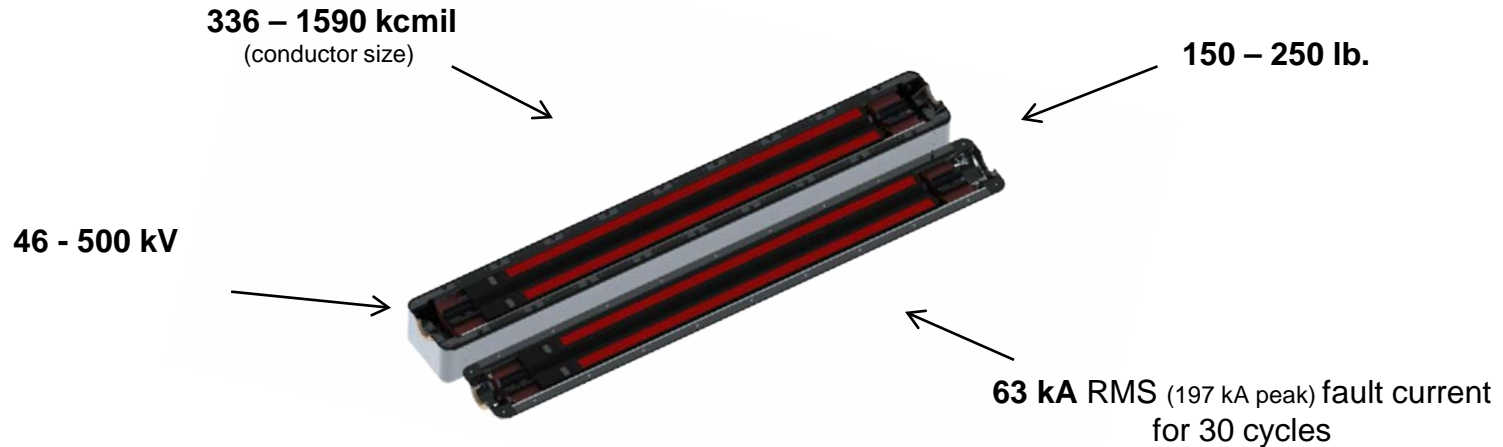


## Supplemental Material

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## DSR Specifications



- Life: 20+ year life, zero maintenance
- Fault response: Automatic transition from injection to monitoring mode in  $\ll 5$  ms
- Conductor configuration: Compatible with single or multi-conductor circuits
- Conductor impact: No mechanical or thermal conductor degradation
- Environmental: Resistant to salt fog, Aeolian vibration, ice buildup, thermal cycling
- EMI: No corona at operating voltage
- Power: Harvested from the line current
- Wind loading: Up to 150 mph (250 kph)
- Communications: Specified by owner

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