CAPER

Center for Advanced Power Engineering Research

2017 Summer Research Planning Workshop

Cost-Benefit Analysis for DER Integration: A Case Study

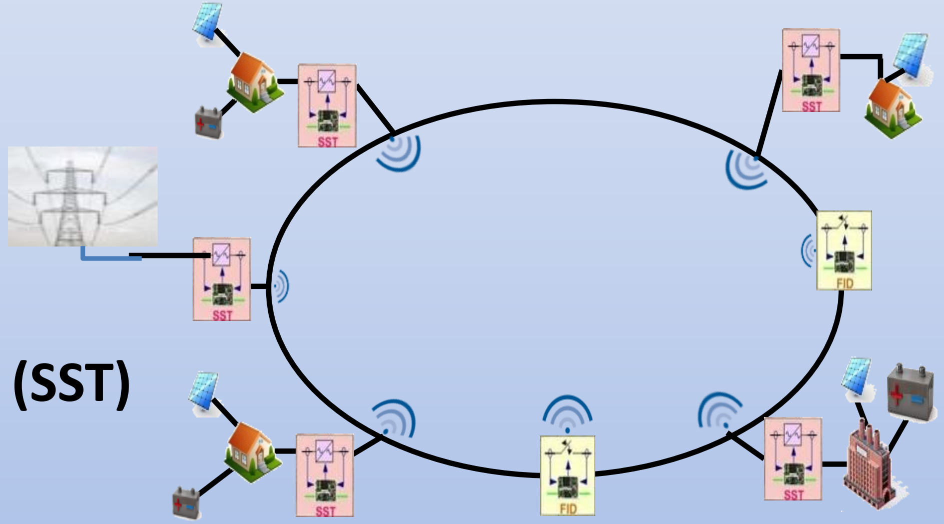
Mesut Baran

FREEDM Systems Center, NC State University

baran@ncsu.edu

Case: FREEDM System

- FREEDM facilitates DER integration



- **Solid State Transformer (SST)**
  - Voltage regulation
  - Volt-Var Support
  - Fault Current Limiting & Isolation
  - Communication interface

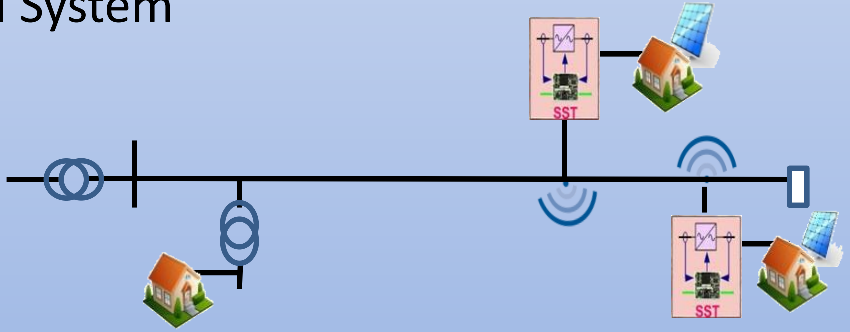
Cost Benefit Analysis for FREEDM System

Goal: **quantify the value proposition of the FREEDM System**

- Challenge: Multi-disciplinary team: engineering, economics, and marketing
- Market: Distribution circuit with high DER penetration

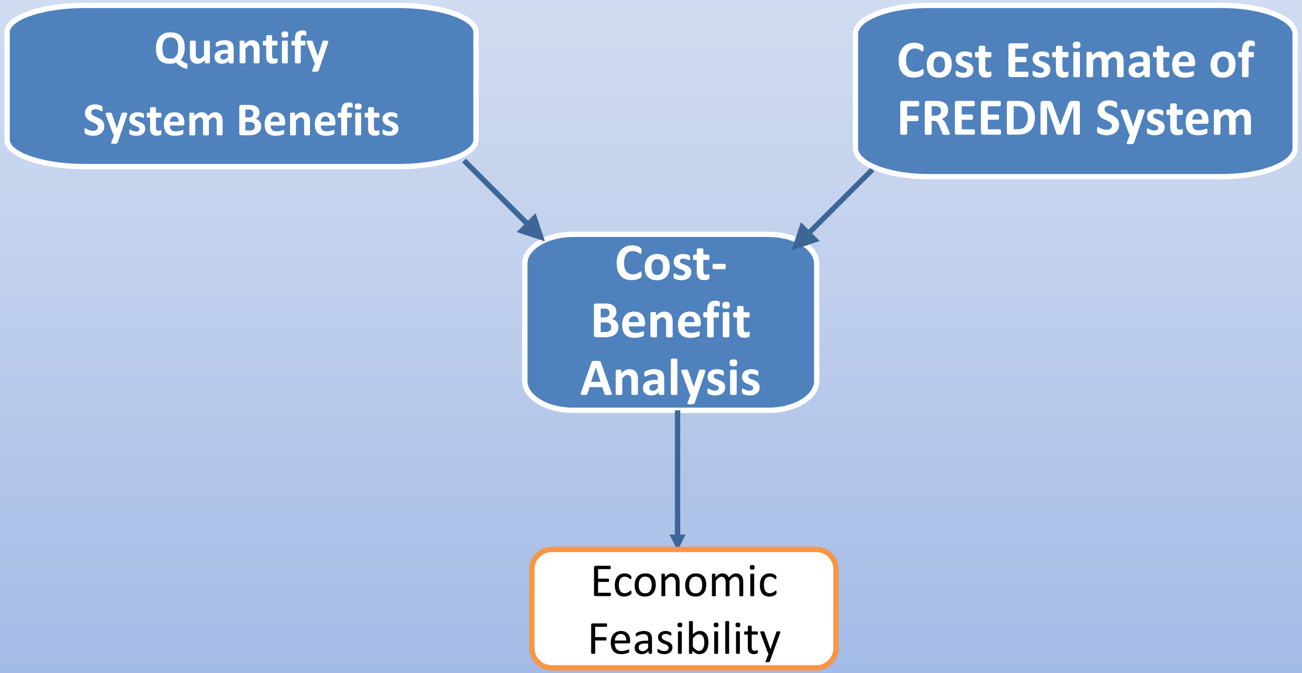
→ Circuit needs enhancements to host high DER

→ Partial FREEEDM System Deployment



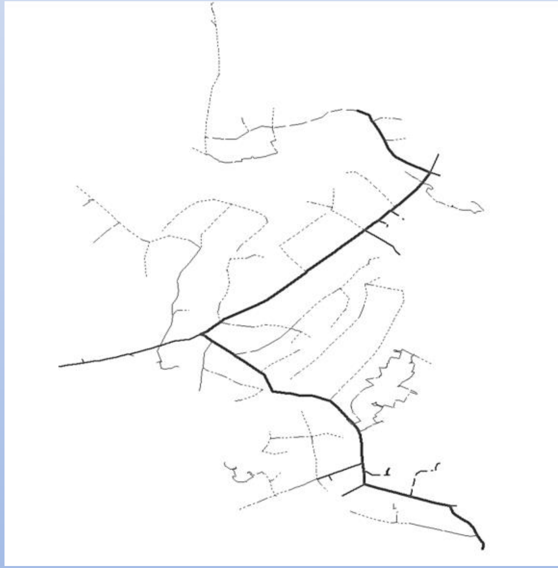
CAPER

CBA Approach

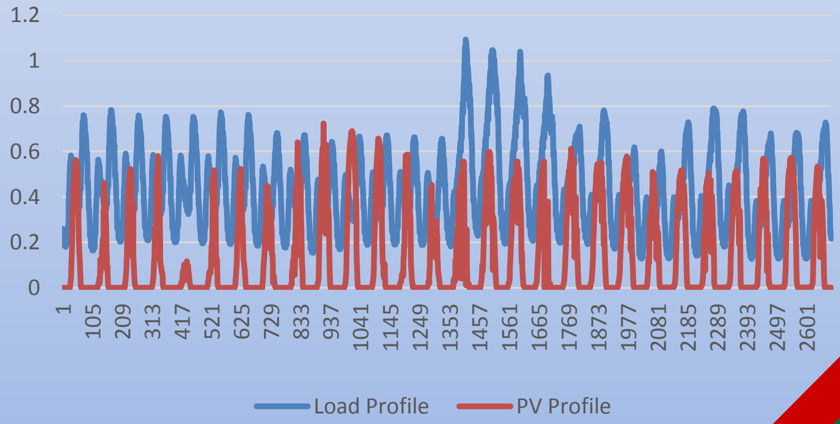


FREEDEM Benefits

- System: 3 actual utility feeders



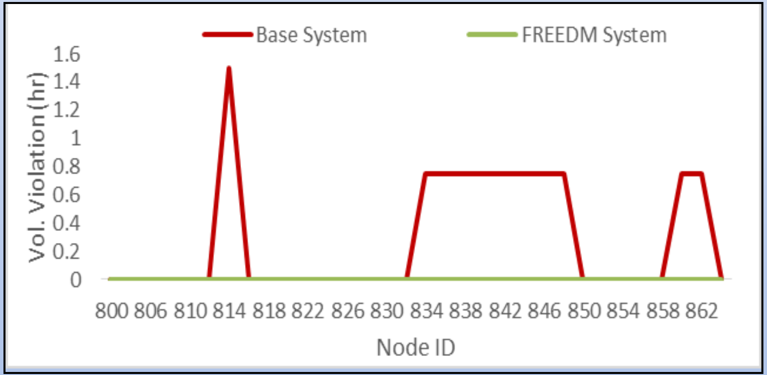
- Approach:
  - simulate high PV penetration
  - time series simulation of the system over a year



FREEDEM Benefits

Benefits Considered

- Mitigating Voltage Violations (increase hosting capacity)



- Power & Energy Reduction (due to Volt-Var & CVR)

CAPER

Simulation Results

	SSTs Used	Overvoltage reduced (% time/yr.)	CVR ΔV	Energy MWh-yr.	Peak Pwr kW	Losses MWh-yr.		
						Line	XFMR	Total
Circuit A	32	2.70%	3.8V	-1,721	-147	0	-17	-17
Circuit B	16	0.40%	4V	-1,452	-92	-4	-21	-25
Circuit C	58	1.32%	4V	-1,903	-165	-15	-20	-35

→FREEDM System

- Effective overvoltage mitigation → increase Hosting Capacity
- Improve system efficiency

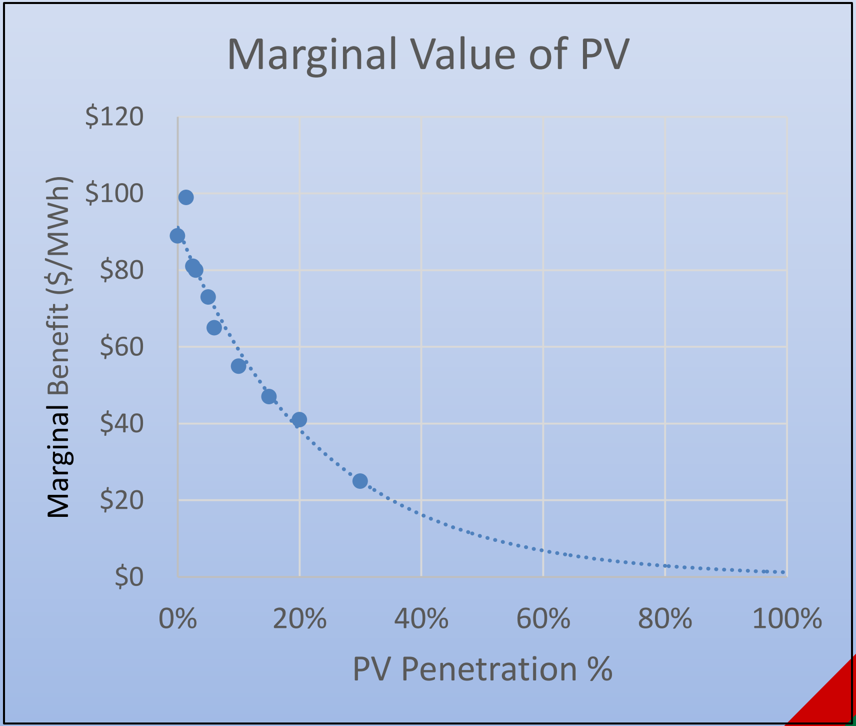
System Benefits

- PV benefits/cost on Gen & Trans:
  - Avoided energy costs
  - Deferred investment in capacity expansion
  - PV variability
- FREEDM allows higher level of PV

Integration of marginal value curve between 50% and 100% yields total benefit available through additional PV

- Annual benefits to utility: ≈ **$10,000**

PV valuation studies



CAPER

FREEDM Costs

SST:

Cost estimation performed with data from present design and market costs

Assumptions: Manufacturing and component costs, 15 year time horizon, 0.9 maturity factor, and 31% gross margin

SST	List Price (15 y)
20 kVA, 1Ø	$3,103
50 kVA, 1Ø	$4,653
75 kVA, 1Ø	$7,830
100 kVA, 1Ø	$15,794
150 kVA, 3Ø	$10,924
Energy	
Peak	$51 / MWh
Off-Peak	$33 / MWh
Demand	
Peak	$100 / MW
Off-Peak	$34 / MW

- Costs associated with feeder upgrades

One-time costs

- Installation of upgrade devices
- Required ancillary components
- Stranded assets

Recurring costs

- Maintenance of upgrade devices
- Replacement of residual distribution transformers

- Key Assumptions
  - 25 year lifetime of upgrade devices
  - Upgrade devices require maintenance every 5 years

Economic Assessment

- A dynamic spreadsheet tool was developed for economic assessment metrics & sensitivity analysis

FREEDM SYSTEM COST BENEFIT ANALYSIS - DECISION SUPPORT WORKBOOK

Economic Parameters		
Discount Rate		10%
Lifetime (years)		25
Capital Charge Rate		0.1102

System and Cost Characteristics		
System	LSSS	
Ownership Scenario	Customer: Storage & PV	
Cost Model	High Deploy	

ANNUAL COSTS		
Category	Unit	$/year
Capital Costs	$	$ 176,903
Annualized Capital	$/year	$ 19,489
Annual Loss	$/year	$ 149
Maintenance	$/year	$ -
Resident Cost	$/year	$ 648,000
Total Annual Cost	**$/year**	**$ 19,638**

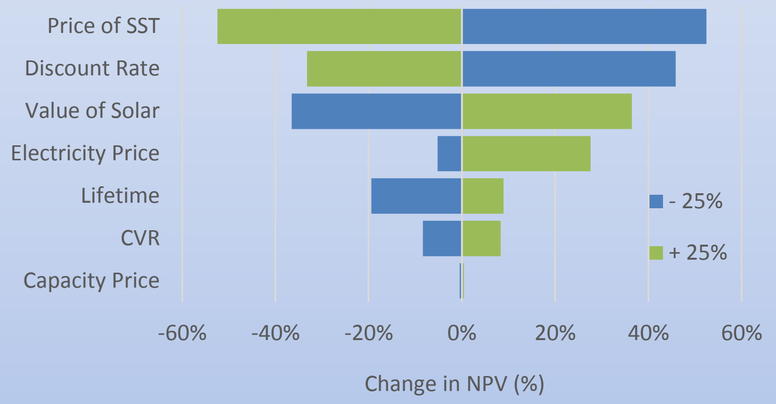
Financial Calculations		
Net Present Value	$	$ (80,668)
IRR	%	10.59%
Payback Period	yrs	22.2

ANNUAL BENEFITS			
Category	Energy	Demand	Other
Volt-Var Control (VVC)	$ 2,298	$ -	$ -
DGI Price Signals (DSM) - Customer	$ 437	$ -	$ -
DGI Price Signals (DSM) - Utility	$ -	$ 25	$ -
Energy and Peak Demand Reduction (CVR)	$ 6,088	$ 182	$ -
Reliability - Customer	$ -	$ -	$ 703
Reliability - Utility	$ -	$ -	$ 1,183
Incremental Solar	$ 10,757	$ -	$ -
SUM (UTILITY)	$ 19,143	$ 206	$ 1,183
SUM (CUSTOMER)	$ 437	$ -	$ 703
TOTAL ANNUAL BENEFITS (UTILITY)	**$20,532**		
TOTAL ANNUAL BENEFITS (CUSTOMER)	**$1,140**		

MAIN | BENEFITS | Benefit List | COSTS | System Char | CF | VVC | DSM | CVR | Reliability | Solar | Cost Avoidance | Loa ...

CBA Results

Financial Metric	Circuit 2
NPV (25 yr)	$ 670
DPBP	2.9 years



Ref: L. Sun, et al, "Cost-Benefit Assessment Challenges for a Smart Distribution System: A Case Study, PES GM 17

Thanks !