

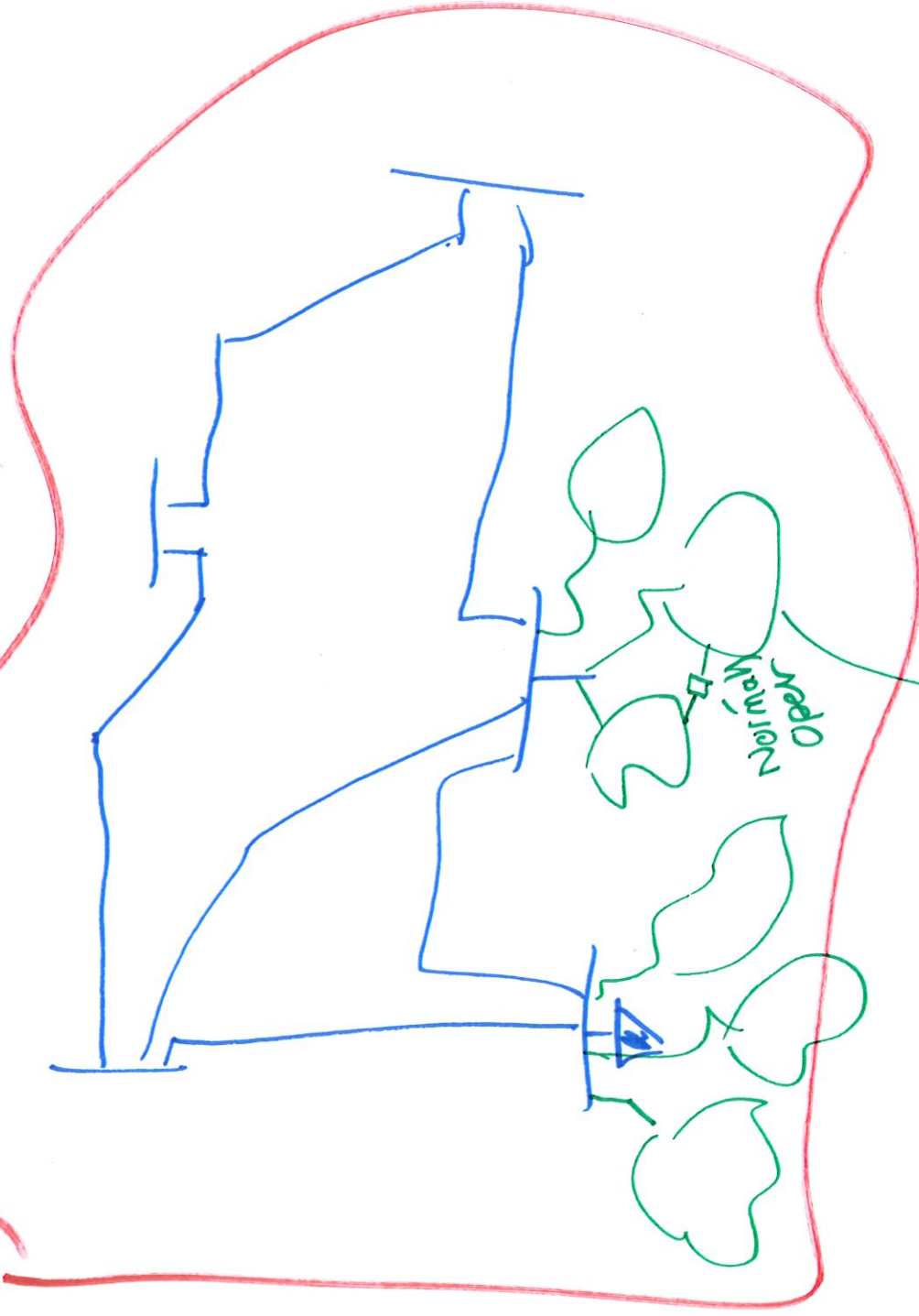
ECE 444 / ECE 544 /

CS 444 / CS 544

Supervisory Control and Critical Infrastructure Systems

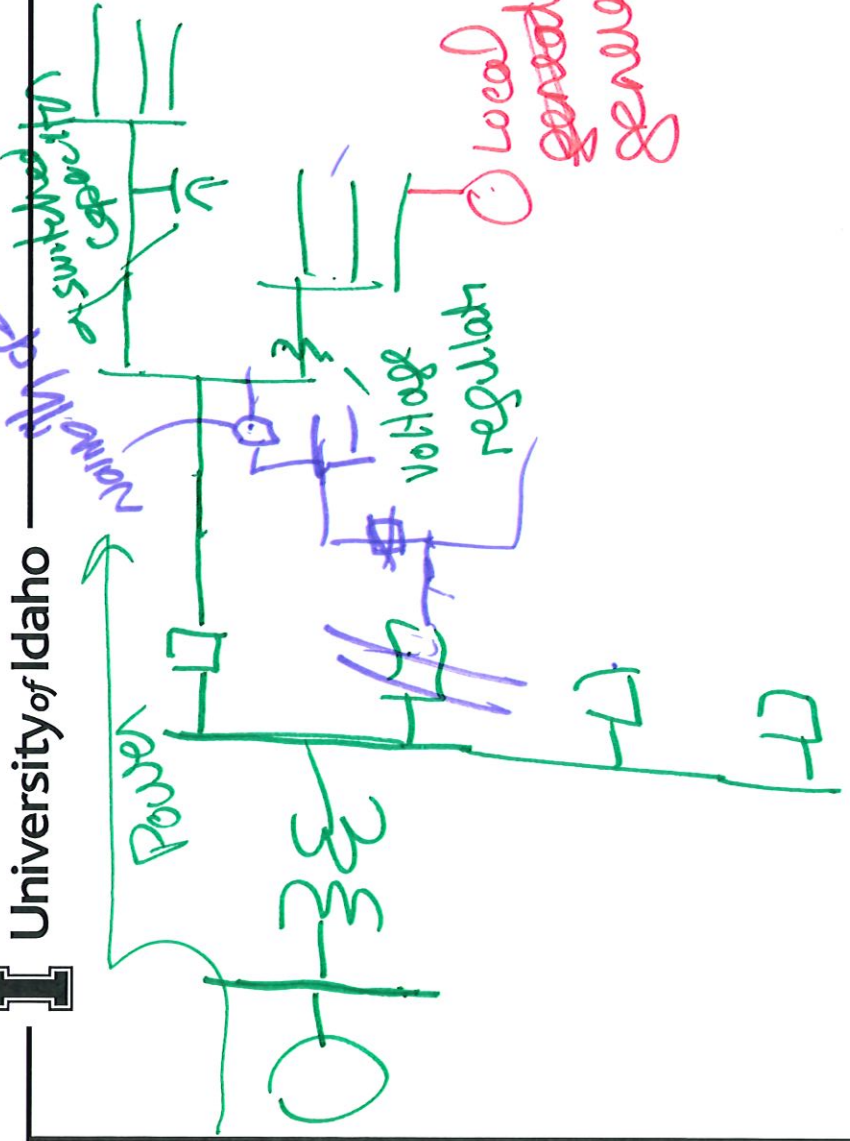
Session 26

Utility



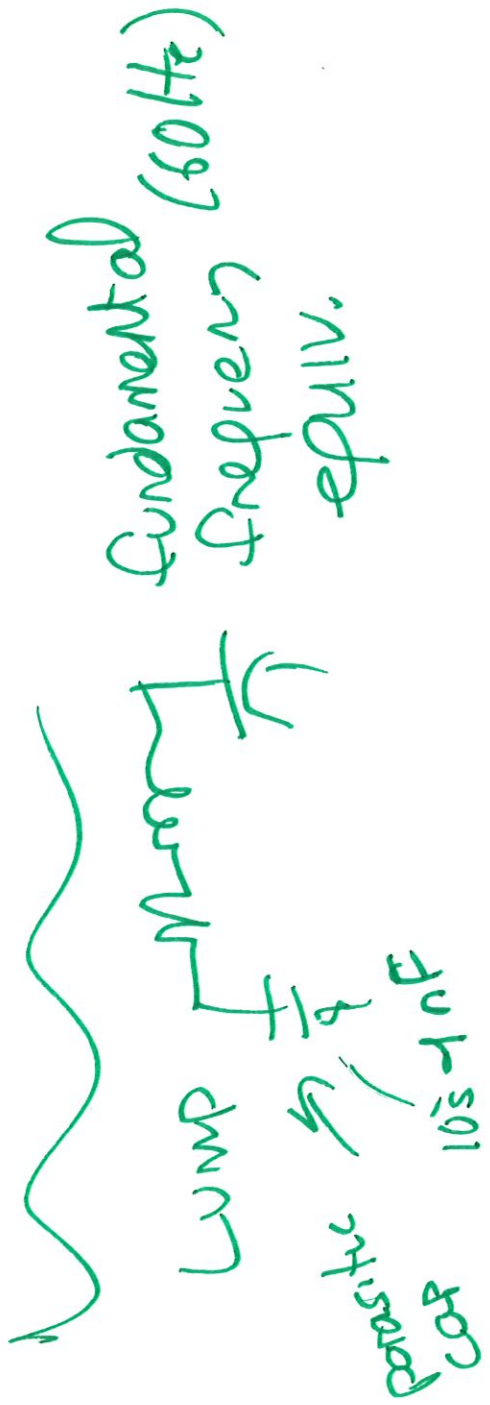
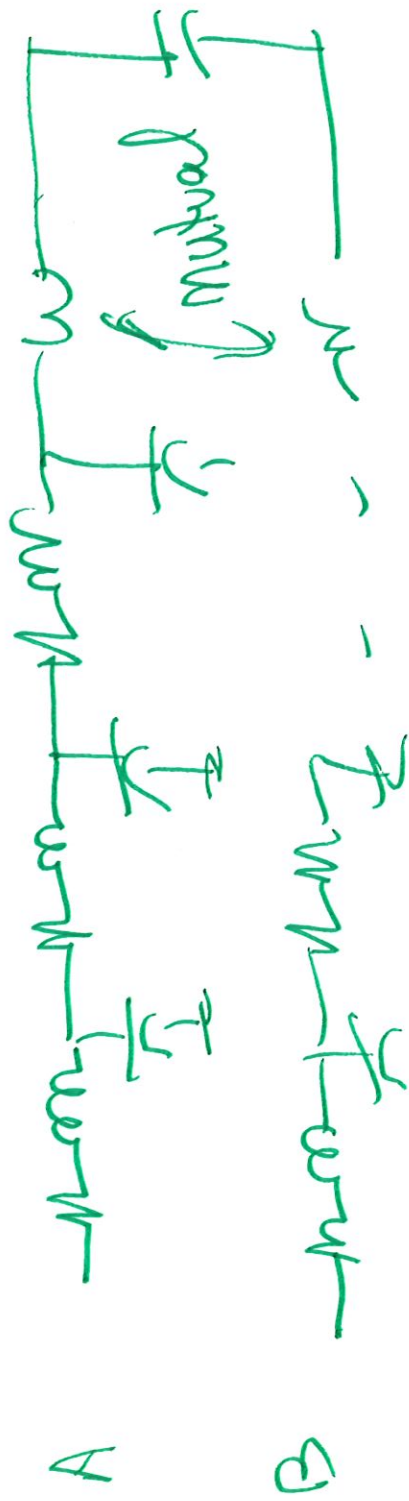
distrib. systems

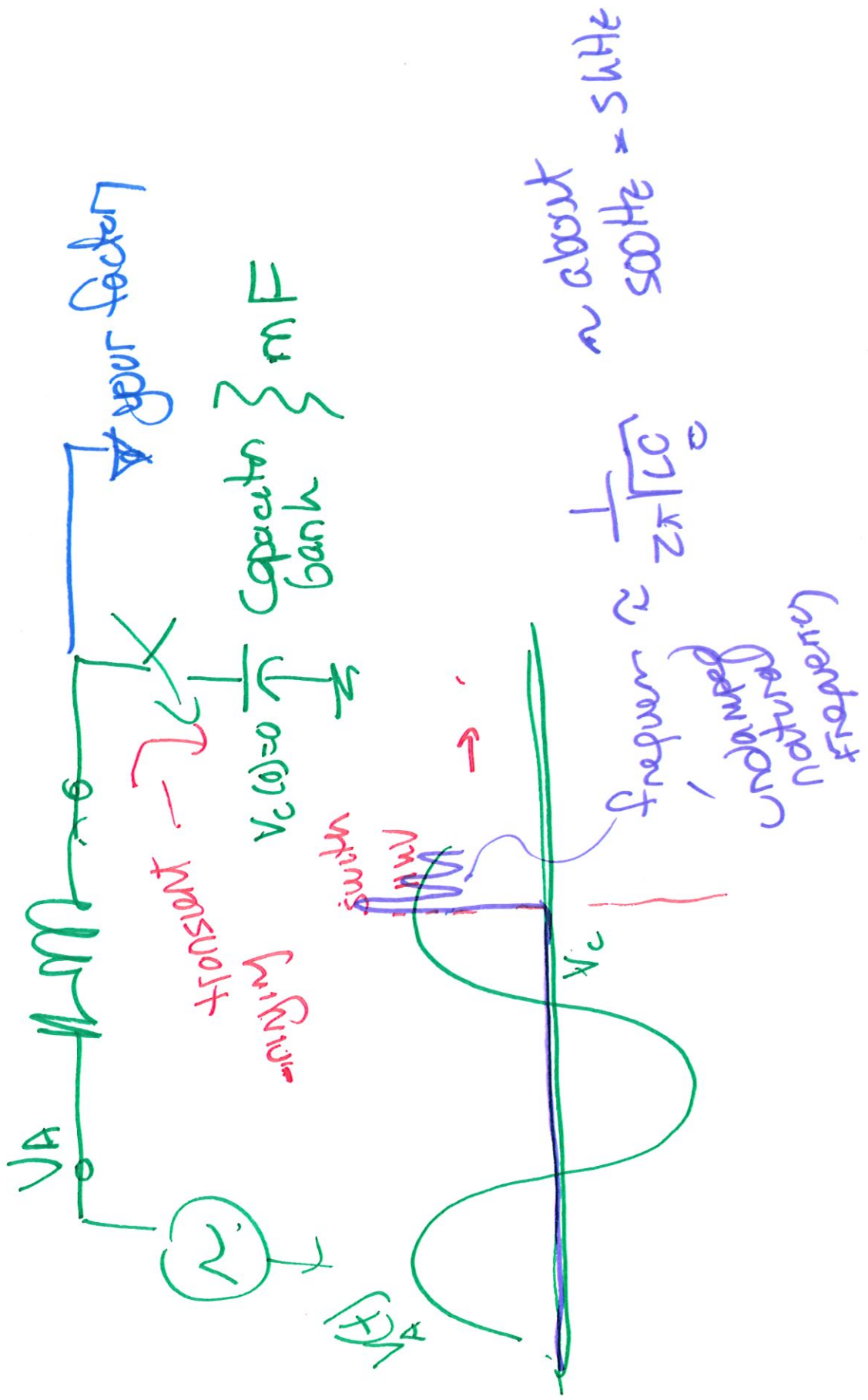
Radical Systems



Distributed generator
 ⇒ Distributed Resources
 ⇒ Distributed energy resources

power conductors





6/9
126
927

60 Hz

11 Hz

60 + 11
60 - 11

Synchro-waveforms: Possible Applications CS&ECE 444/544

Lecture 26

- Analyze response of IBRs (inverter based resources)
 - » Fault response
 - » Disturbance response
- System response characterization
- Low frequency oscillations
- Oscillation source
- Protection
- Control

From: H. Mohsenian-Rad and W. Xu, "Synchro-waveforms," *IEEE Power & Energy Magazine*, Sept/Oct 2023

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3
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3

- communication -
- control -

Growing Interoperability Needs Beyond the Substation CS&ECE 444/544

Lecture 26

- Transmission control devices, energy storage, HVDC, etc.
- Technology interoperability needs PV, wind, etc
 - » Harmonized plug and play solutions
 - » Compliance of same or different technologies
 - AC and DC systems
 - Testing
 - Modeling for planning/operations studies
- Vendor interoperability
 - » Operation compatibility of same technologies from different vendors
 - » Compatibility of different technologies from different vendors
- Testing → who and where

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Digital Twins

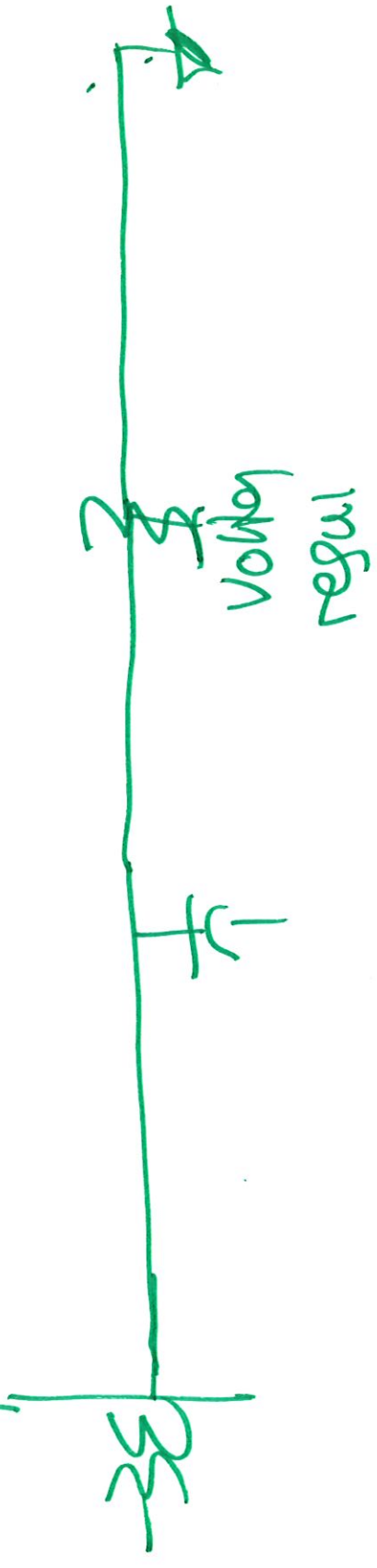
3rd party labs - real time simulators - produce waveforms that can interact with control hardware in real time

2

voltage magnitude by location



Elaborate profile with more devices
 smaller simpler devices



6/1/27

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Distribution Systems

- Large amount of equipment and circuits
- Communication and automation can have local impact = *starting to look at impact on larger system*
- Often less visibility on distribution system prior to last 10-15 years
 - » Cost versus benefit

less measurements of communication
An coordinated control

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Distribution Applications: Some History

- Initially little communication within distribution system
- Some utilities looked at demand side management
 - » 1980's
 - » Power line carrier, some radio
 - » Control water heaters or air conditioners to reduce load peaks *reduce peak load*
- Digital metering
 - » Drive by versus communication network *smart meters*
- Voltage control
 - » Conservation voltage reduction (old name)
 - Integrated Volt Var Control
 - » Coordinate capacitor banks/voltage regulators
 - » Starting to add inverters

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evolved to demand response
- voluntary control
→ signal from
- Building Energy Management

6

6/8 8/9
L26 227

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Lecture 26

Many More Distribution Applications

- Fault location, identification and system reconfiguration (FLISR)
- Outage management systems (OMS)
- Distribution management systems (DMS)
- Smart meters—how get data to OMS and DMS?
- And so on....
- Coordination of these tools
 - » Many have their own communication and databases
 - » Advanced distribution management systems (ADMS)

- combining all of these functions

Enterprise system
not operational
tech

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7

in to one umbrella
- one database
- one comms

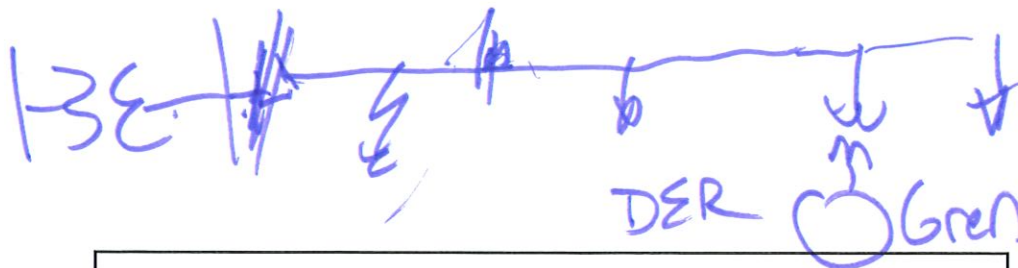
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Distributed Energy Resources

- Integration and Coordination of distributed energy resources (DER)
- Distributed generation
- Energy storage
- Demand response
- Could be a bunch of stand-alone devices
- Could coordinate...
 - » DERMS - DER management systems
 - » Microgrids

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6/6 927

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Microgrids

- Growth of non-utility owned generation with move toward re-regulation of utility industry (PURPA)
- Public Utility Regulatory Policies Act of 1978 initial step
 - » Encouraged industry facilities to install generation and sell to grid
- 1990's significant increase in interest in distributed generation
 - » Starting to see increase in renewable, but mostly rotating machine
 - » Big concern at the time was unintentional islanding—detection and isolation

I IEEE Standard 1547 development - evolved to enabling distributed energy res

• IEEE 2030 → communications, including security

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9

2030.1, .2 --

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Initial Concepts

- DOE working groups and IEEE groups started looking at creation of intentional islands
 - » Sufficient location generation to support loads
 - » Much of initial discussion looked at distribution systems
- Coining of the term Microgrid

2 intentional islands

I

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