

Impacts and Needs for Renewables in Distributed Generation

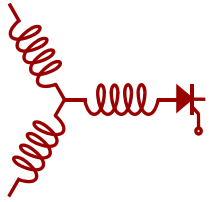
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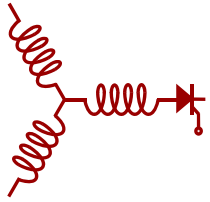
University of Wisconsin-Madison





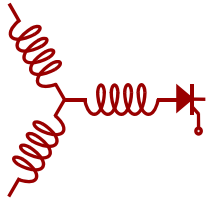
What is DREG?

- Distributed Generation
 - Interfaced to the distribution system
 - Close to load centers
 - Low voltage network
 - Small size
- Renewable Energy
 - Derived from natural processes
 - Replenished continuously
 - Sustainable use and harvest



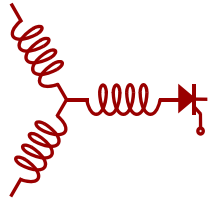
DREG Technologies

- Solar Photovoltaic/thermal
- Biomass
- Biofuels
- Geothermal
- Micro-hydro / Run of the river
- Wind
- Waves and tides
- CHP
- V2G

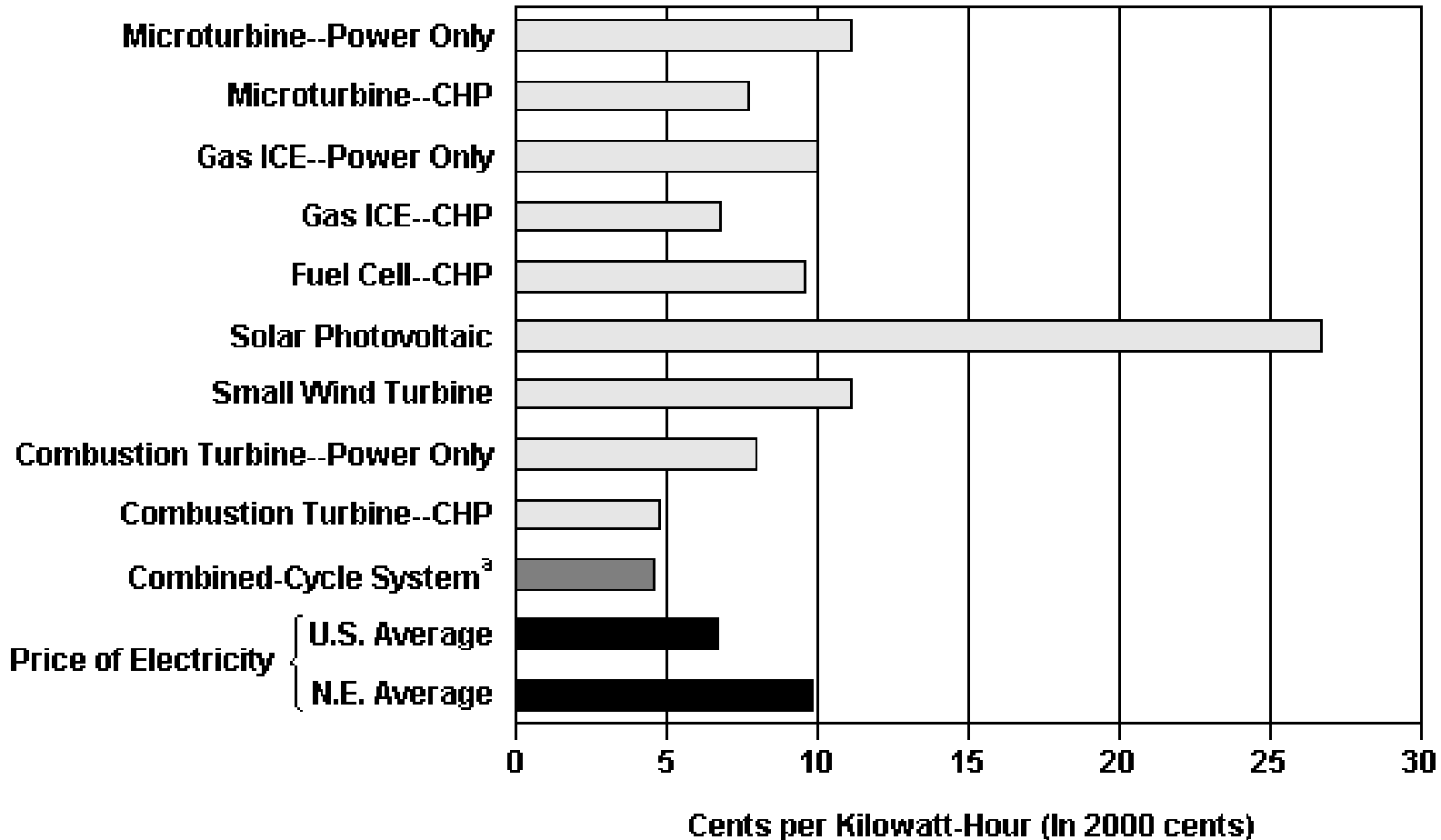


DREG Application Locations

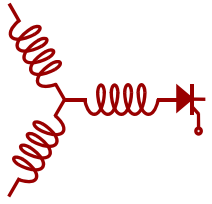
- Residential
- Commercial
- Community/District
- Industrial
- Substation
- Urban/Rural



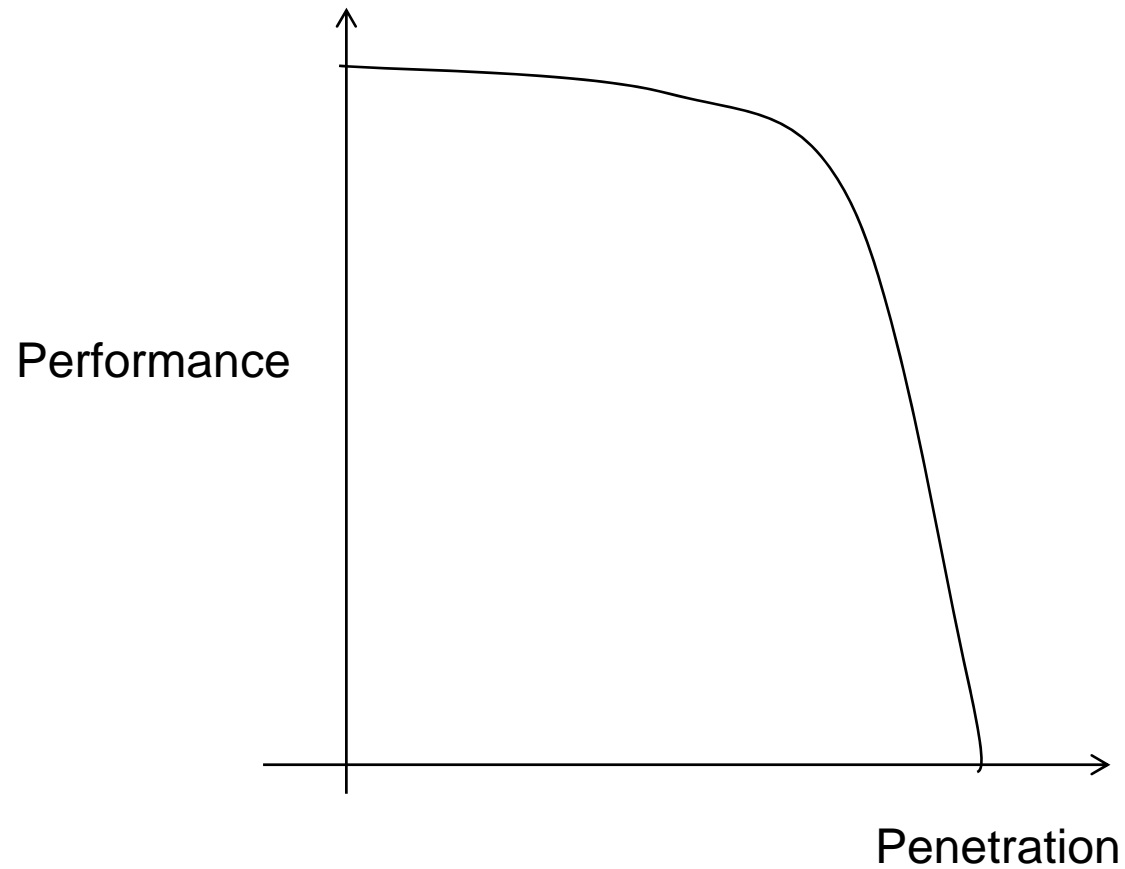
DREG State of Art

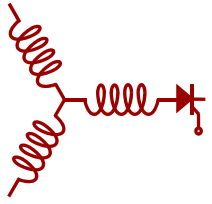


From: Congressional Budget Office, [Prospects for Distributed Electricity Generation](#), September 2003



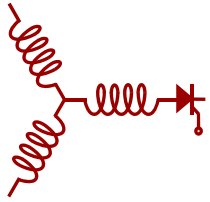
Growing pains – Uncertainty





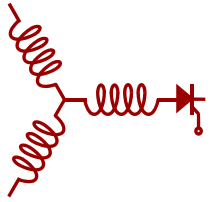
DREG challenges and concerns

- Energy balance
- Steady state operation
- Transients and dynamics
- Protection and safety
- Operations, regulations, economics



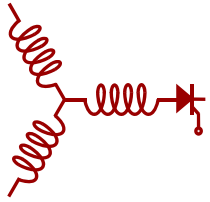
Energy balance

- Stochastic variations in demand
 - Historical data and experience
- Stochastic variations in generation
 - Short and long term variability
 - Weather and climate uncertainty
- Regulation reserve
- Storage
- Load shifting
- Geographical mismatch



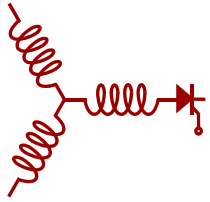
Steady state operation

- Capacity of distribution infrastructure
 - Substations
 - Transformers, conductors, switchgear
 - Thermal limits
 - Overnight cool-down
- Voltage profile
 - Radial system with drooping voltages with distance
 - Transformer LTC and capacitor switching
 - Voltage rise and regulator interactions



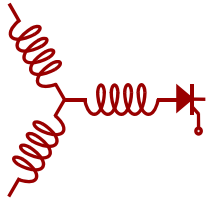
Transients and dynamics

- Steady state system stability
 - Frequency regulation
 - Voltage regulation
- Transient stability
 - Load changes
 - Fault recovery
 - System restoration – cold load pick-up
 - Switching transients



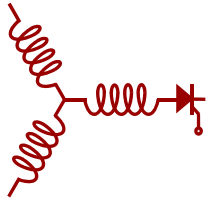
Protection and safety

- Increased short circuit currents
- Bi-directionality
- Coordination of relaying
- Fault management
- Ride-through
- Unintentional islanding



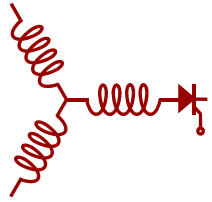
Operations, regulations, economics

- System management
- Ancillary services
- Metering
- Tariffs
- Investments
- Interconnection standards
- Operation standards
- Market access and service innovation



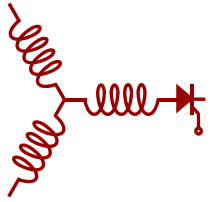
Inversion of penetration conditions

- LSE into DGO
- Transformation
 - Radial energy delivery system into a real-time energy exchange
 - Energy retailer into transactional agency
- Distribution Grid Operator



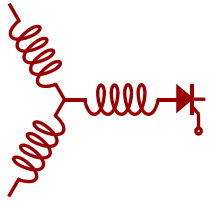
Enabling Concept - Microgrid

- Empower each power source to self regulate
 - Active power/frequency droop
 - reactive power/voltage droop
- Allows autonomous operation of multiple heterogeneous sources in a stable manner
- Use hierarchal layered approach to manage energy balance



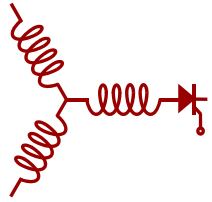
ePod

- Energy arbiter for each 'billable' entity
- Use wireless network with Internet Protocol
- Interface with loads, sources within the microgrid and DSO
- E-commerce portal with real time transactional capability



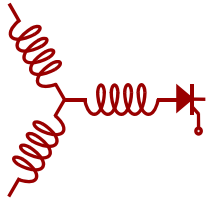
Signaling

- Energy management using frequency proxy signals
 - High power frequency – excess power available – consume NOW, at a lower price
 - Low power frequency – reduce load – wait until LATER or pay higher price now
 - Storage and load compatible
- Slower set point signals may be transmitted using asynchronous wireless protocols
- Blanket broadcast during contingencies



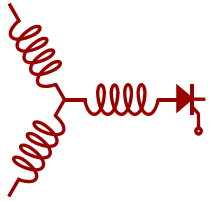
E-Commerce

- \$/W transactions similar to mobile phone tariffs
 - any frequency (nega)watts
 - low frequency (nega)watts
 - high frequency (nega)watts
- Prepaid credits/debits
- Penalties for exceeding agreements
- May include V2G ‘mobile billable entities’



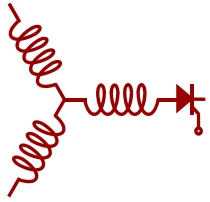
DSO responsibility

- Manage system
- Upkeep infrastructure
- Retail energy
- Interface with bulk producers/consumers
- Invest in and manage storage system
- Provide financing
- Make \$\$



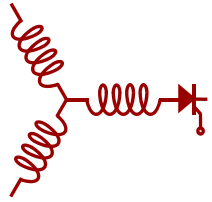
Where are we today?

- Microgrid
 - laboratory demonstration – 2002
 - captive demonstration – 2006
 - enabled products – 2004-2006
 - Microgrid utility scale demonstration – in pipeline
- Ongoing lab research
 - energy management layer
 - Price signaling
 - Storage integration
 - Heterogeneous/autonomous source operations



Where do we need to go?

- Demonstrations and *i/e*-integration
 - energy management layer using power-frequency droop control
 - Price signaling using power-frequency droop control
 - Storage integration using power-frequency droop control
 - Heterogeneous/autonomous source operations



Distributed Renewable Energy Generation

- From SREG
 - Scattered Renewable Energy Generation
- To PREG
 - Pervasive Renewable Energy Generation
- Questions?
- Comments?