Distributed Energy and Power Stability Challenges for the Electric Grid

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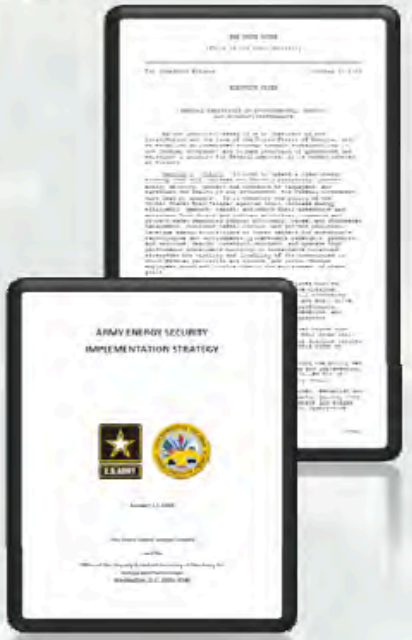
Army Microgrid Motivation

- DoD Policy Goals
  - EISA 2007, EPAct 2005, Ex. Order 13514
- Energy Security
  - AESIS
  - Surety, Survivability, Supply, Sufficiency, and Sustainability
- Renewables Integration
  - Economic Optimization
  - Operation without Grid Support
- Evolving Energy Market Participation
  - Demand Response, Peak Shaving
  - Real Time Pricing
  - PHEV, BEV Integration



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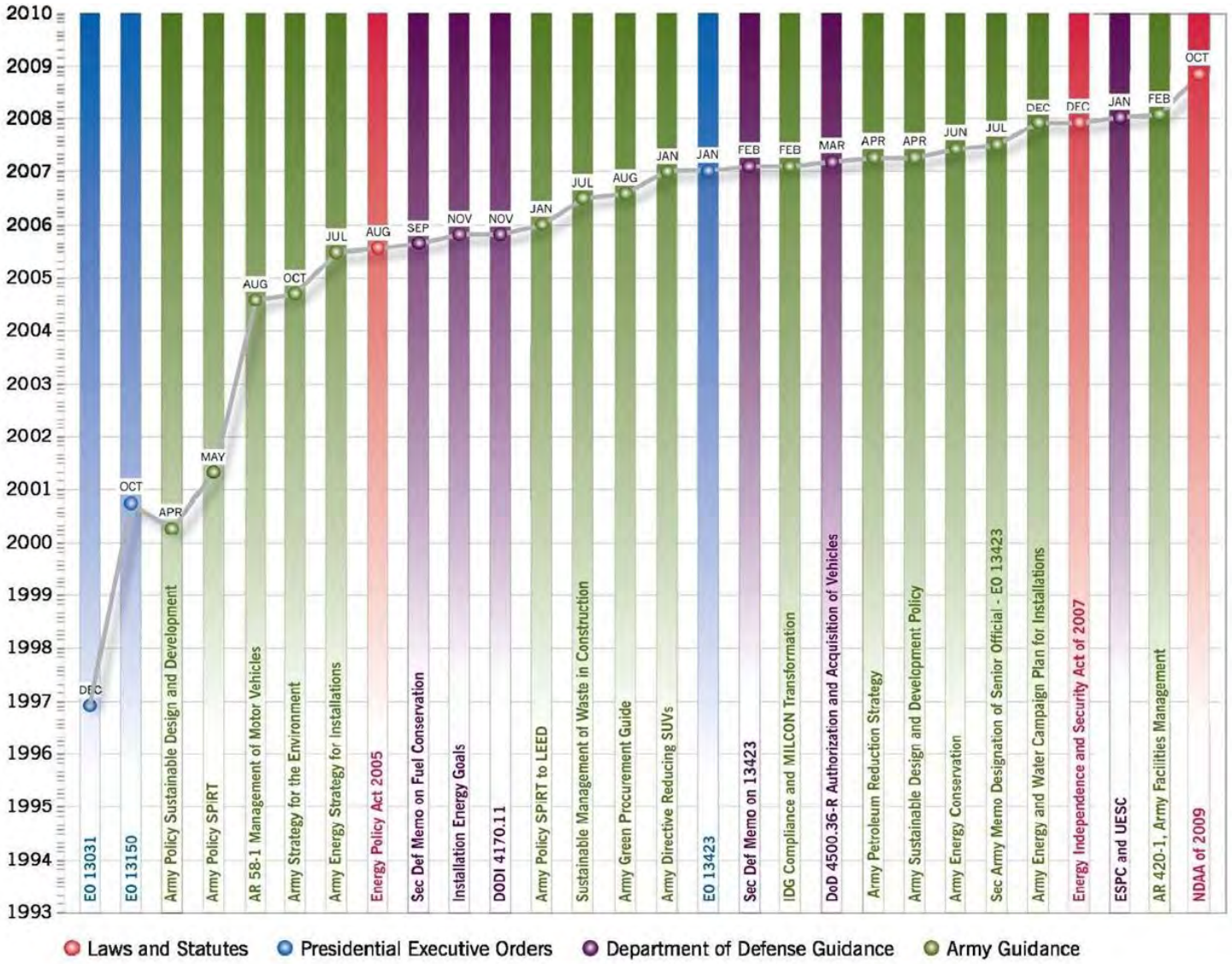
DOD Renewable Energy Goals



Problem Statement

Unlike conventional sources of generation, renewable energy sources are not directly "dispatchable" (output power is not easily controlled/predicted)

- *Transient/seasonal* effects and limited predictability can result in intermittency
- *Intermittency* can be detrimental to short term grid stability and long term reliability
- Unconventional Protection Schemes
- Operational *Safety* for Power System Personnel

Challenges (Short Term Effects)

As renewable energy sources increase (as a percentage of total generation) the following effects can result:

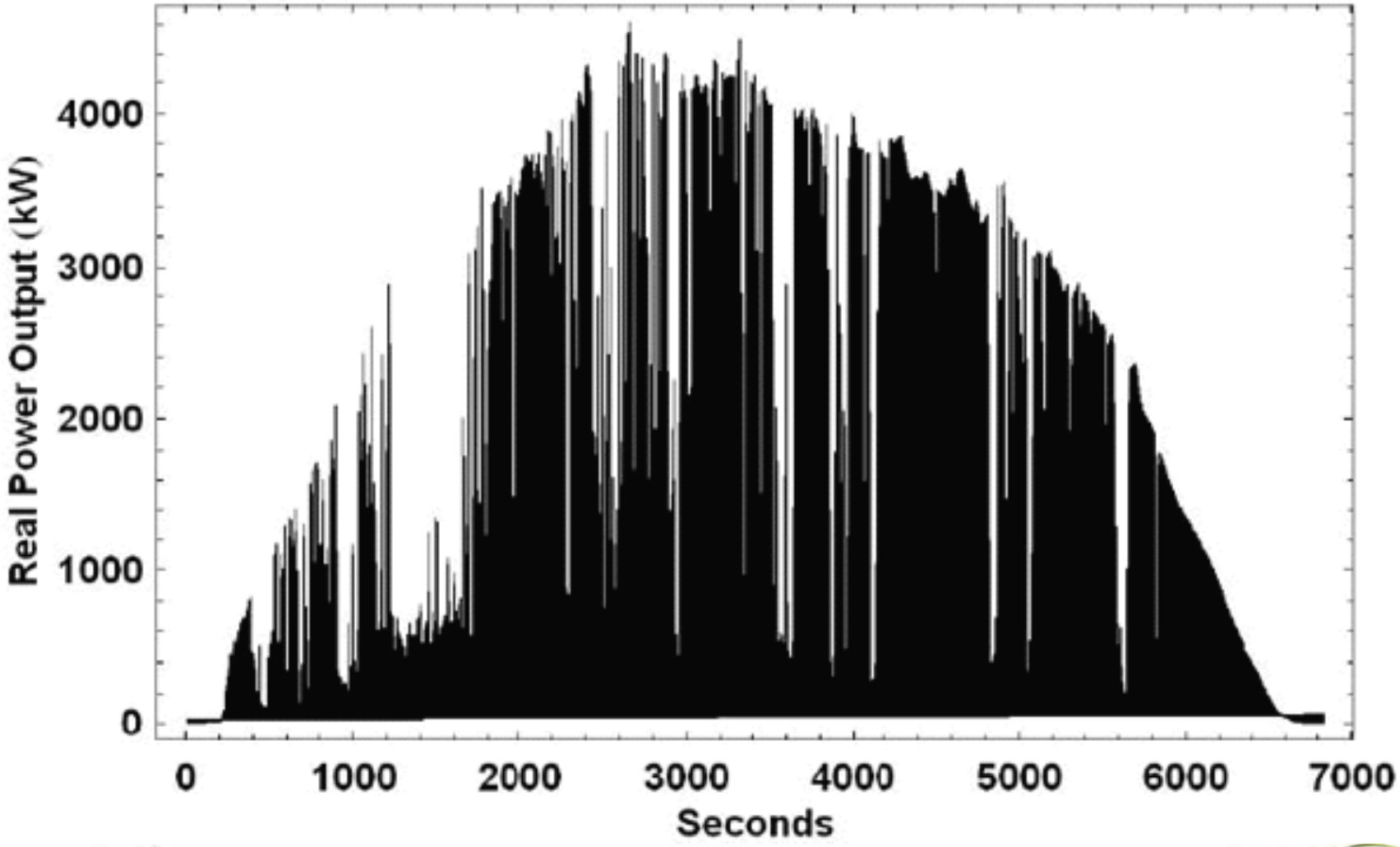
- Increase in PE based/inverter based generation
- Decrease in prime generation as a percentage of load (conventional rotating inertia based generators)
- Produce Reverse power flow conditions and effects on protection relays.
- Adverse effects on existing protection systems – possible malfunctions to protection equip if DER is not adequately considered in high level system protection scheme

Challenges (Long Term Effects)

- As renewable energy sources increase (as a percentage of total generation) the following effects can result:
  - Potential for increased variation between available power on grid and electrical demand
  - Variability may eventually overwhelm the ability of conventional generation assets to compensate for renewable instability

- Microgrids and Islanding
  - Large networks of DERs are programmed to disconnect/reconnect with grid for bulk power variations and swings

Challenges



Solar photovoltaic power from a large,4.6 MW system (Springerville, AZ) demonstrates intermittency. - - Solar PV output presented over one day (10 second resolution)

Needs (Capability Gaps)

- Intelligent energy network management (over long and short time scales) to monitor and control operating parameters to maintain stability

- Capability to seamlessly integrate supporting infrastructure (e.g. energy storage, EVs, inverters) to support load shifting, displacement and arbitrage, and phase balancing. However, current cost of many storage technologies is high

- Even distribution/penetration of renewables, optimized location of storage and placement of conv. rotating generation

Short Term Mitigation Strategies

- Strategic Integration of Energy Storage
  - ES can support additional capabilities
    - Responsive Load following/ramping
    - Load Shifting
    - Capacity displacement and arbitrage,
    - Ancillary Services
      - Many current ES soln's remain prohibitively costly
- Improved accuracy of weather/renewable forecasting (both spatial and temporal)
- Increased spinning reserves (specifically in advance of anticipated events: storms, weather conditions, etc)
- Operational practices with increased safety margins, (SS operation further from stability thresholds)

Long Term Mitigation Strategies

Enabling Capabilities:

- Protective relaying schemes with specific emphasis on renewables and DG.
- Less costly energy storage, with embedded control to support automatic DR, load shifting, etc.
- Superconducting Materials (to facilitate bulk distribution of renewable energy distribution over longer distances
- Distribution systems to include more automated, extensive directional relaying, pilot signal relaying, automated, communication-based transfer trips,

Long Term Mitigation Strategies

Current Guidance:

– IEEE 1547.x

– UL 1741

Further Engagements and Collaboration Opportunities for Standards Development:

– NIST SGIP

– IEEE PES

Questions?

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