

Advanced Energy

The Power of Choice[™]

Universal Interconnection Technology

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Small is Beautiful

***We need methods and equipment
which are:***

- Cheap enough so that they are accessible to virtually everyone;**
- Suitable for small scale application; and**
- Compatible with man's need for creativity**

(E.F. Schumacher, 1973)

Why Distributed Generation?

Security

- Power Supply Reliability**
- Power Quality**
- Immunity from Attack**

The National Research Council has recommended that we “Develop, Test and Implement an intelligent, adaptive electric-power grid”

Intelligent, Adaptive Power

Recommendation 16: Technology should be developed for an intelligent, adaptive power grid that combines a threat-warning system with a distributed-intelligent-agent system. This grid would be able to rapidly respond with graceful system failure and rapid power recovery. It would make use of adaptive islanding—a concept employing fast-acting sensors and controls to “island” parts of the grid as the rest comes down—and technologies such as storage units positioned at key points to minimize damage during shutdown. The system would need to be able to differentiate between a single component failure and the kind of concurrent or closely coupled serial failures at several key nodes that would indicate the onset of a concerted attack.

The Environment (& More Schumacher)

- ***Atmospheric Pollution***
 - **Small scale operations, no matter how numerous, are always less likely to be harmful to the natural environment than large-scale ones, simply because their individual force is small in relation to the recuperative forces of nature.**
- ***Reduced use of Non-Renewable Resources***
 - **It is clear that the “rich” are in the process of stripping the world of its once-for-all endowment of relatively cheap and simple fuels.**

Lower Costs!

- Lower Design Costs**
 - Shorter Time to Market**
 - Standardized Components**
 - Higher Efficiencies(?)**
 - Heat Recovery (CHP)**
 - Lower Distribution Losses**
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Summary of *Why* -> *How*

DER Devices must be:

- Secure (providing reliable, high quality power and immunity from attack)**
 - Flexible (capable of feeding the grid and operating in intentional islands)**
 - Efficient & Cost-effective**
 - Renewable & Sustainable**
 - Safe**
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Technology - Some Issues are Solved:

- ***1547 will specify voltage and frequency trips***
 - ***Current controlled inverters are common – THD requirements can be met***
 - ***Adequate anti-island techniques have been developed***
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... And Some are Not:

- ***Multi-Inverter Islanding is not addressed***
 - ***Methods of controlling microgrid and intentional islands***
 - ***Standard Procedures for Testing***
 - ***DC Injection & DC on the grid***
 - ***1547 Certified Controllers***
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Current Myths

- ***Voltage and Frequency Protective Relaying can provide reliable anti-islanding protection***
 - ***UL1741 Island Tests are sufficient to ensure multi-inverter protection***
 - ***Induction Generators cannot Island***
 - ***Islanding is unlikely to occur***
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Islanding - Key Issues

- ***The basic problem is solved and becoming well understood***
 - ***AEI Patent covers feedback and acceleration concepts (the Sandia Methods)***
 - ***Need to prove viability at high penetration***
 - ***Need to model stability in the wide-area grid***
 - ***Multi-inverter systems / Multiple methods***
 - ***Testing (test setups, procedures, motor tests)***
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Anti-Islanding Primer

- ***Passive Trips (Voltage and Frequency)***
 - ***Phase Jump Detection***
 - ***Harmonic Monitoring***
 - ***Impedance Measurement/Power Shifting***
 - ***Reactive Power Feedback***
 - ***Real Power Feedback***
 - ***Direction and Acceleration***
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Islanding - Known Problems

- ***Flicker***
 - ***Dilution of power shifting methods***
 - ***Thresholds***
 - ***Quantization***
 - ***Inadequate feedback***
 - ***Incompatibility of different methods***
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Islanding Conclusion

- ***Ultimately, we need to adopt a method, not a performance test***
- ***We must base future work on theory, not on experimentation***

DC Injection

- ***Many inverters can inject DC onto the line
- we need to alter utility procedures***
 - ***Some utilities are questioning non-transformer-isolated designs***
 - ***Need to distinguish between HF isolation transformers with DC output and low frequency transformers***
 - ***Redundant voltage detection might be the solution***
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Microgrids and Intentional Islands

- ***Need to agree on how devices will work together via communications and the electrical interface***
 - ***Must allow for Steady State, Transient and Fault Conditions***
 - ***AEI has been working on this problem for three years with Sandia***
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Certified Controllers

- ***UL Certification Costs are high***
- ***Testing is required for every model***
- ***Our theoretical understanding is becoming sufficient to allow type testing of a controller based on control and anti-islanding methods***
- ***We believe that this is the path to universal interconnection technology***

Communications

- ***P1614 Draft Guide for Monitoring, Information Exchange and Control of Distributed Resources Interconnected with Electric Power Systems***
 - ***Operation/monitoring/Control/Scheduling/Resource Allocation***
 - ***The keys are object modeling and security***
 - ***Please join the working group!***
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Recommended Areas for Research

- ***A standard anti-islanding method that is proven in the multi-inverter case***
- ***Control schemes for microgrids and intentional islands***
- ***Certified controllers***
- ***Test procedures***
- ***Communications protocols and object model***
- ***Cryptographic techniques such as SSL for use in micro-controller-based DER communications devices***

Conclusion

There is a wisdom in smallness if only on account of the smallness and patchiness of human knowledge, which relies on experiment far more than on understanding.

(E.F. Schumacher)