DYNAMIC MODELING

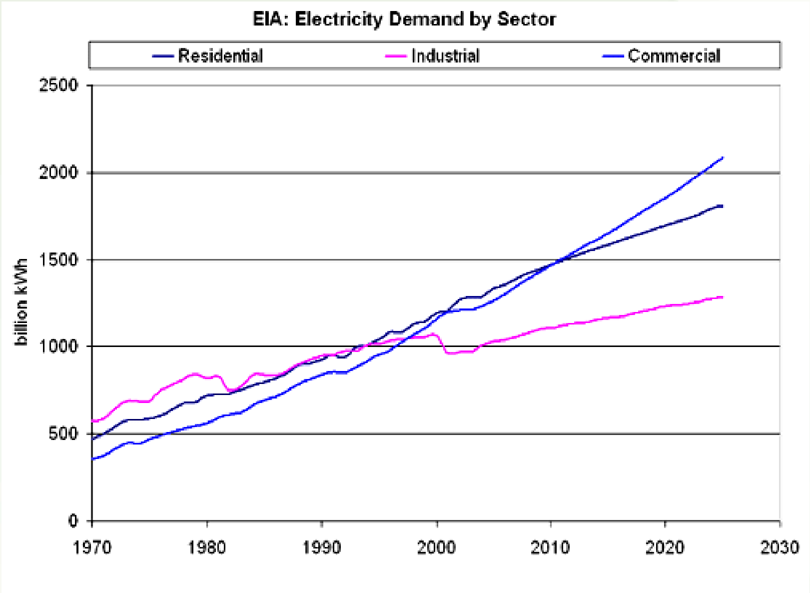
Commercial Office Building Measurements and Dynamic Integrated Distributed Energy Resource Application, Analyses, and Control

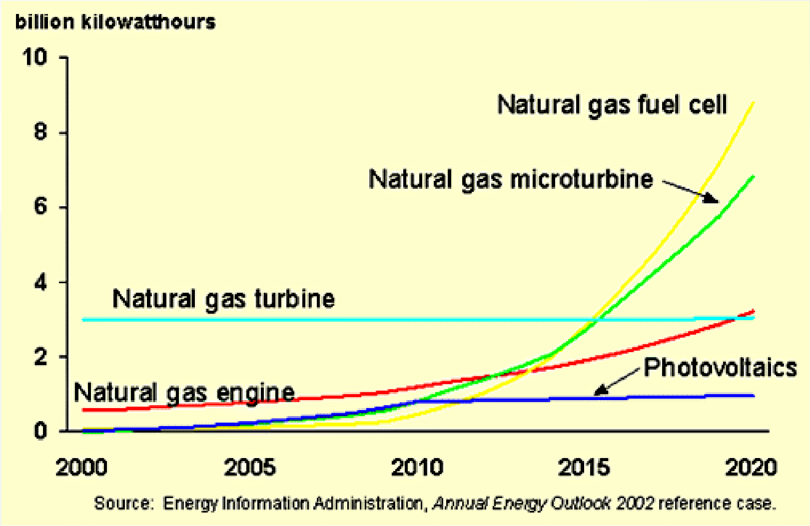
Overview

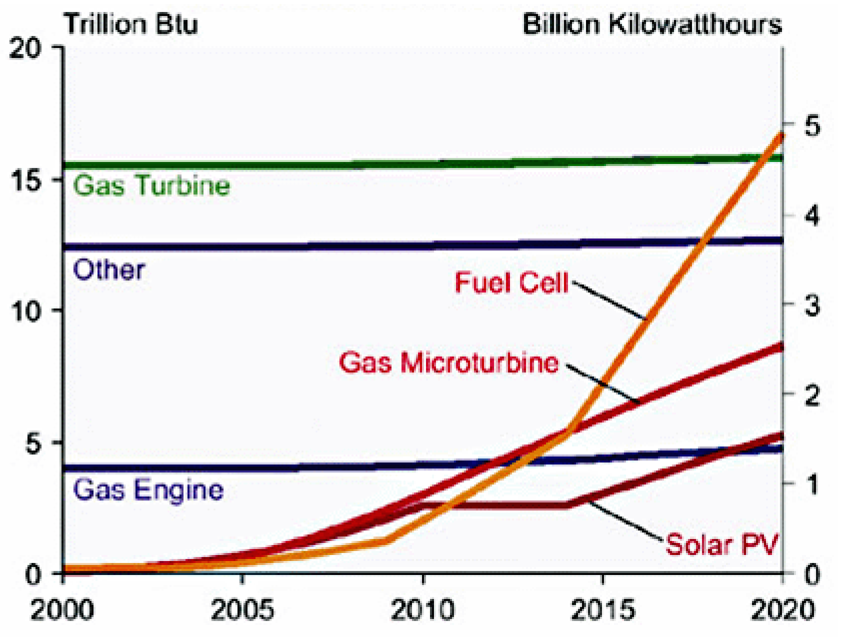
- DG Market Potential
- Key Non-Technical Integration Issues
- Key Technical Integration Issues
- Conclusions and Implications for Hybrids

DG Market Potential

According to the EIA, the majority of electrical demand growth will come from the commercial sector (2.5% growth annually vs. 1.3% for Industrial and 1.6% for residential).

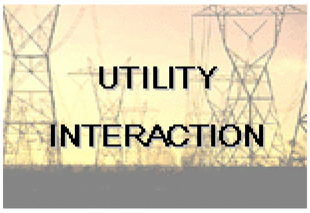






Source: AEO2000 National Energy Modeling System, run AEO2K.D100199A.

Key Non-Technical Integration Issues



Integration Issues: Market Approach

DG technologies must address a “double challenge”

- Creating viable products
- Creating a new marketplace for these products

A well-defined “cradle-to-grave” market approach may be the most significant challenge for successful DG integration.

1. What is the target market and product?

- What attributes are customers most interested in (reliability, cost, environmental signature)?
- What size power blocks make sense?

2. How do you reach the market?

- Who will sell, install, service, and operate your equipment? Are they competent / credible?
- Who will own / maintain the equipment?
- Who will train the installers, distributors, operators and service technicians?

3. How can you reach non-traditional markets?

- Commercial office building increasingly important, but difficult to penetrate because of capital structuring and ideological barriers

Integration Issues: Utility Interaction

DG must be accepted by utility companies or market penetration will be impeded. Key issues:

1. Interconnection

- Interconnection application review fees, interconnection studies, and distribution and interconnection facilities upgrades all mean higher capital costs
- Currently, non-renewable generators cannot sell power back to the grid unless listed as a qualifying facility
- Time

2. Costs

- Standby charges and surcharges are often imposed on DG sites, reducing or removing economic incentives for DG implementation
- Rate schedule choice can be critical to DG success (more in Technical Issues section)

On-site generation of power will result in significantly increased consumption of natural gas (or other fuels). Implications:

1.Fuel risk

- How do customers manage fuel supply risk?
- Are DG technologies fuel flexible?

2.Infrastructure stress

- Can the gas infrastructure handle DG (both on the micro and macro scales)?

3.Natural gas or other fuel costs

- High-volume purchasing (retail vs. wholesale rates)
- Who can represent customers in the commodities markets?

Integration Issues: Regulation

Regulation is necessary to make DG economical and safe, and incentives are needed to help engender the burgeoning market. Key regulatory issues:

1.Interconnection

- Equipment certification, permitting, and siting standards are needed (e.g., IEEE1547)
- Independent system operators (ISO) must be able to manage and accept a role for DG

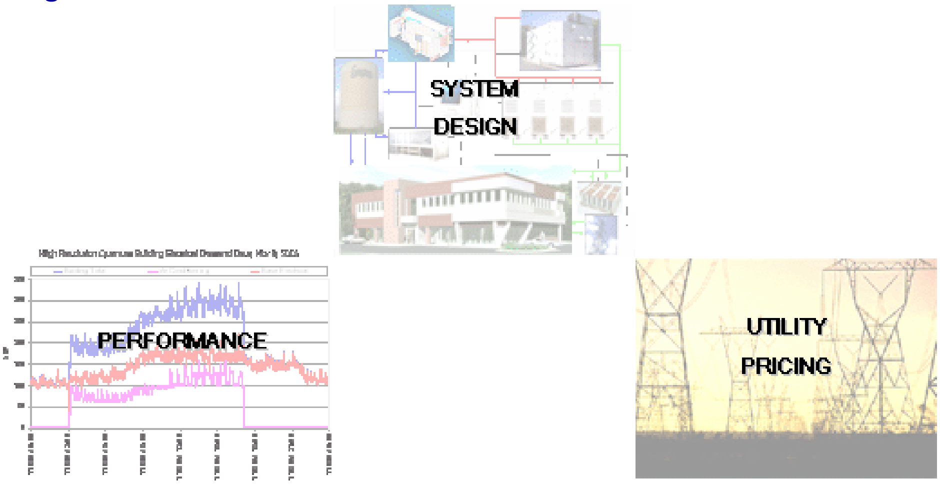
2.Emissions

- Equipment certification, permitting, and siting standards are needed
- Standards for “type certification” (e.g., SB 1298 of California)

3.Incentives

- Needed to help make DG projects more economical, but they must be maintained for many years in order to adequately stimulate the market (e.g., Self Generation Incentive Program (SGIP) of California)

Technical Integration Issues



System Design

Three Primary System Design Issues:

1. End-use load profile

- Electric load profile
- Thermal cooling and heating load profile
- Thermal to Electric Load Ratio (TER)

2. Distributed Generator Attributes

- TER
- Power output
- Performance

3. Other Distributed Energy Resources

- Absorption cooling and heating equipment
- Thermal energy storage
- Electrical energy storage

End-Use Load Profile

Key Aspects:

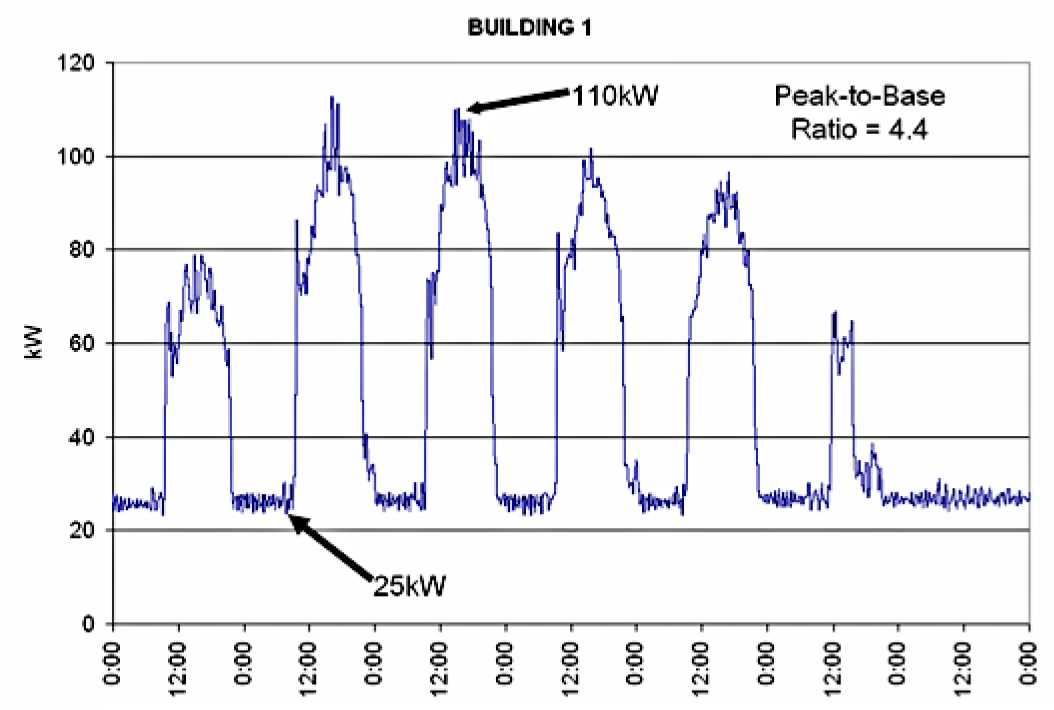
- What is the baseload?
- What is the peak demand?
- How dynamic is the load?
- Can the load (or aspects of the load) be controlled?
- How much heating or cooling is needed?
- Are the electric and thermal loads coincident?
- What is the TER (on average and on peak days)?

UCI Load Profile Engineering Research:

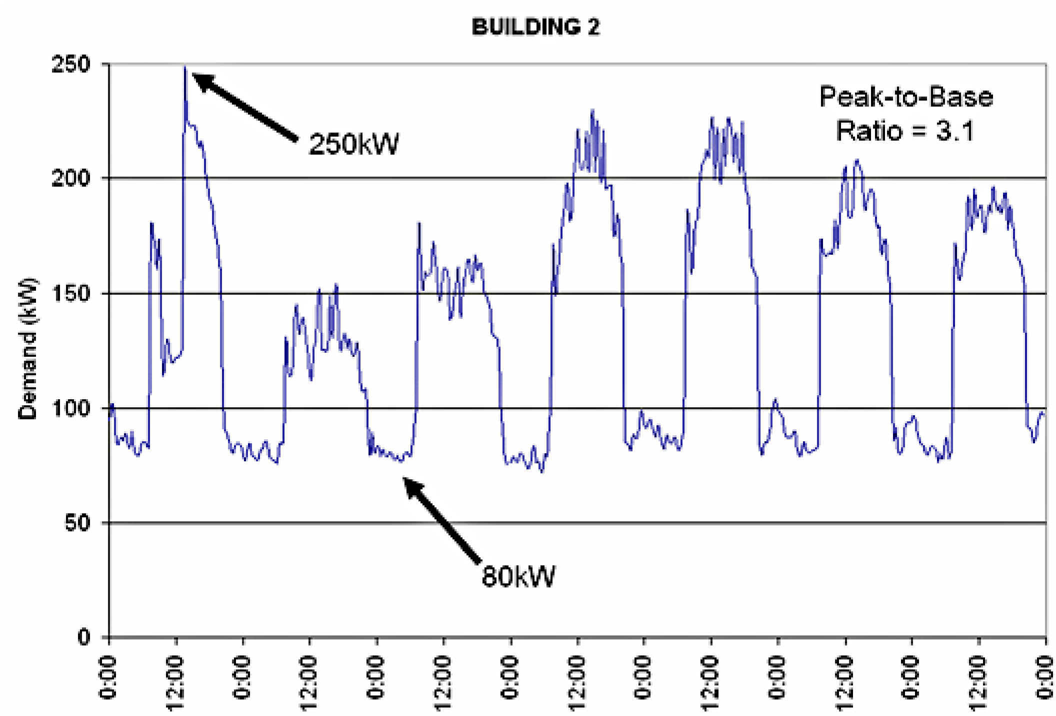
- Building demand data acquisition
- Dranetz PQNode power quality meters
- Dent ElitePro high-resolution power meters
- Separate measurements of thermal (cooling) loads
- System architecture development (e.g., UC Merced, University Research Park)
- Detailed physical representations of DG performance characteristics
- System dynamic simulation

UC Irvine Load Profile Engineering Research:

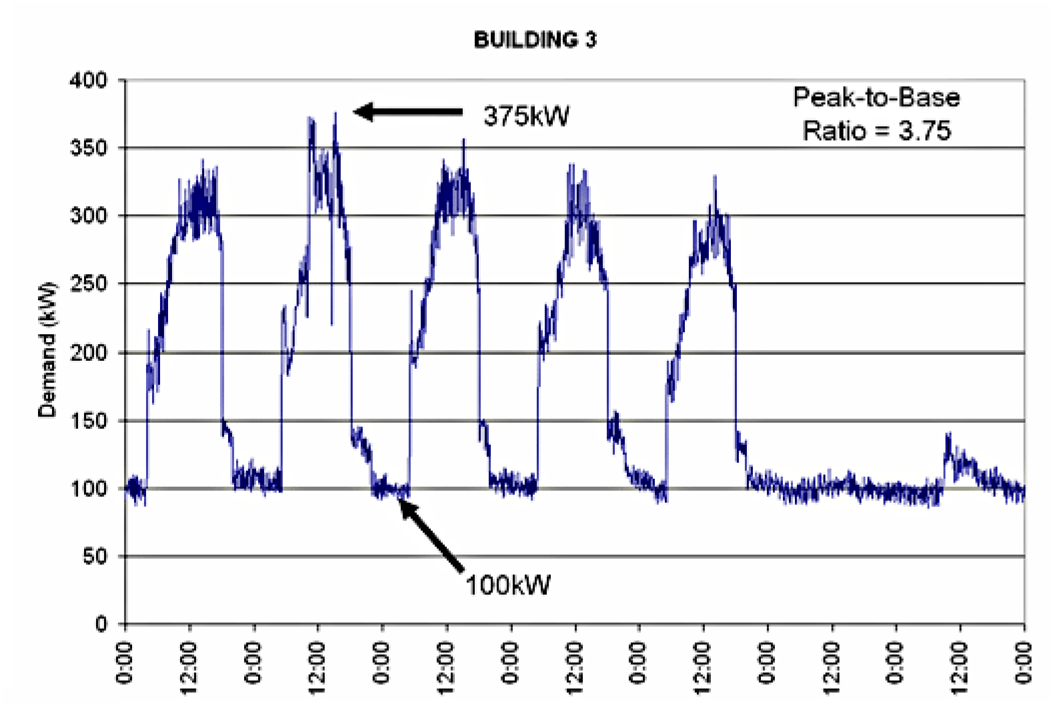
- Continuously monitoring four commercial buildings in the University Research Park for more than 2 years.



BUILDING 1
kW
120
100
80
60
40
20
0
110kW
25kW
Peak-to-Base
Ratio = 4.4
0:00
12:00



BUILDING 2
Demand (kW)
250
200
150
100
50
0
250kW
80kW
Peak-to-Base
Ratio = 3.1
0:00
12:00


BUILDING 3
Peak-to-Base
Ratio = 3.75
375kW
100kW
Demand (kW)
400
350
300
250
200
150
100
50
0
0:00
12:00
0:00
12:00
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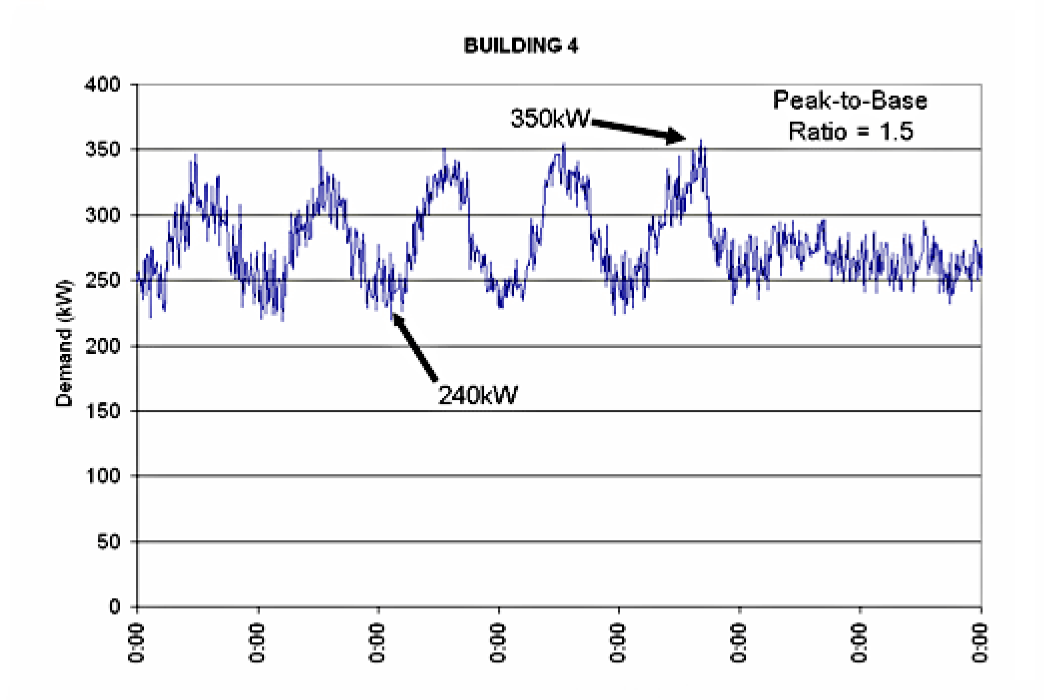
BUILDING 4
Peak-to-Base
Ratio = 1.5
350kW
240kW
Demand (kW)
400
350
300
250
200
150
100
50
0
0:00
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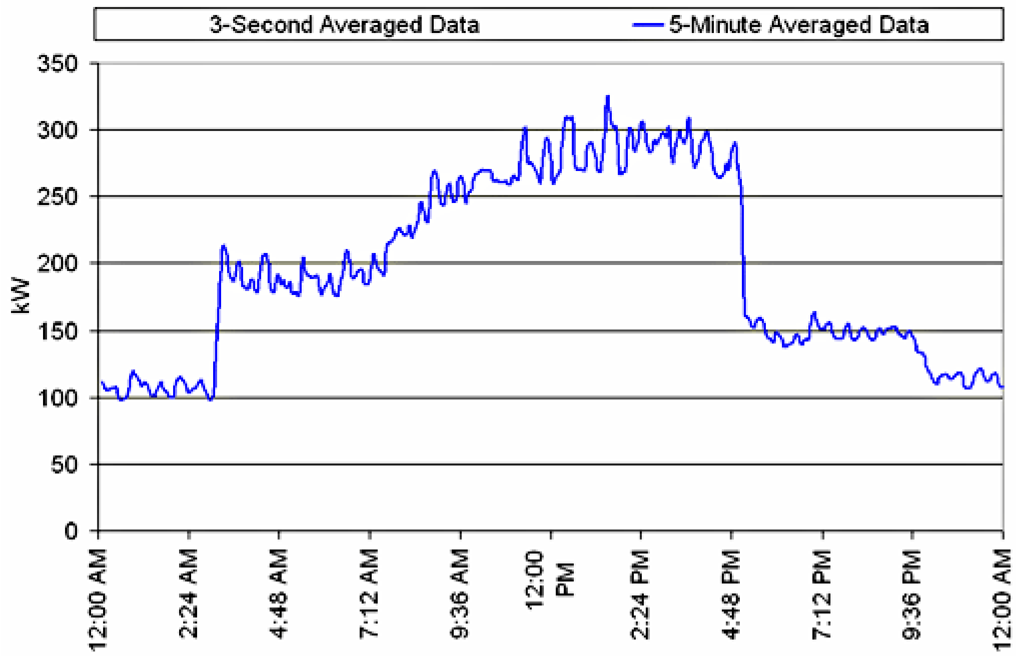
3-Second Averaged Data
5-Minute Averaged Data
kW
350
300
250
200
150
100
50
0
12:00 AM
2:24 AM
4:48 AM
7:12 AM
9:36 AM
12:00 PM
2:24 PM
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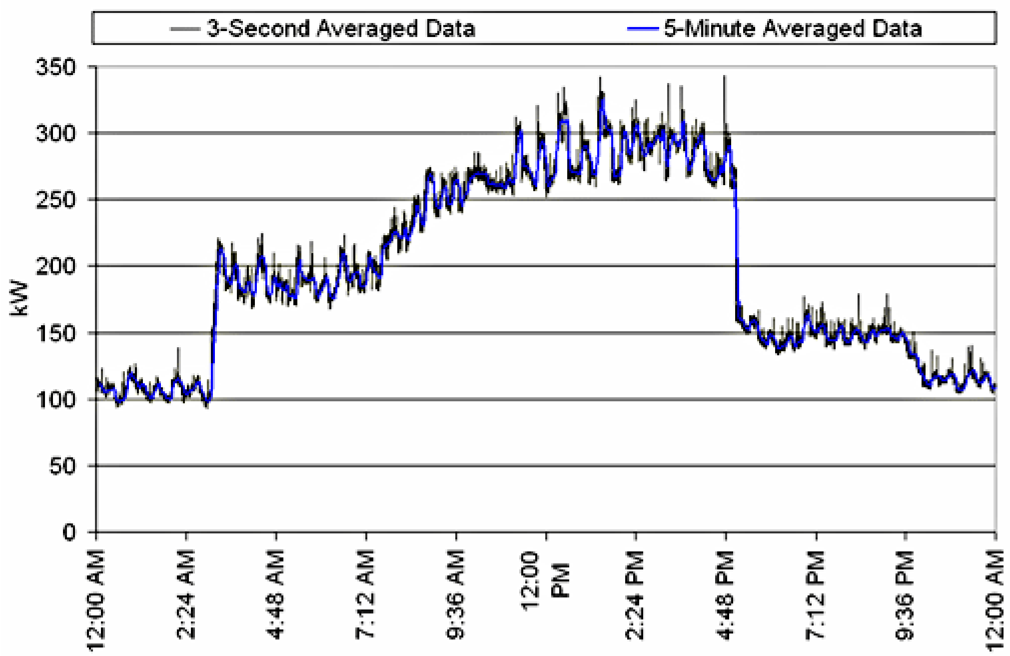
7:12 PM
9:36 PM
12:00 AM


3-Second Averaged Data
5-Minute Averaged Data
kW
350
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12:00 AM
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7:12 AM
9:36 AM
12:00 PM
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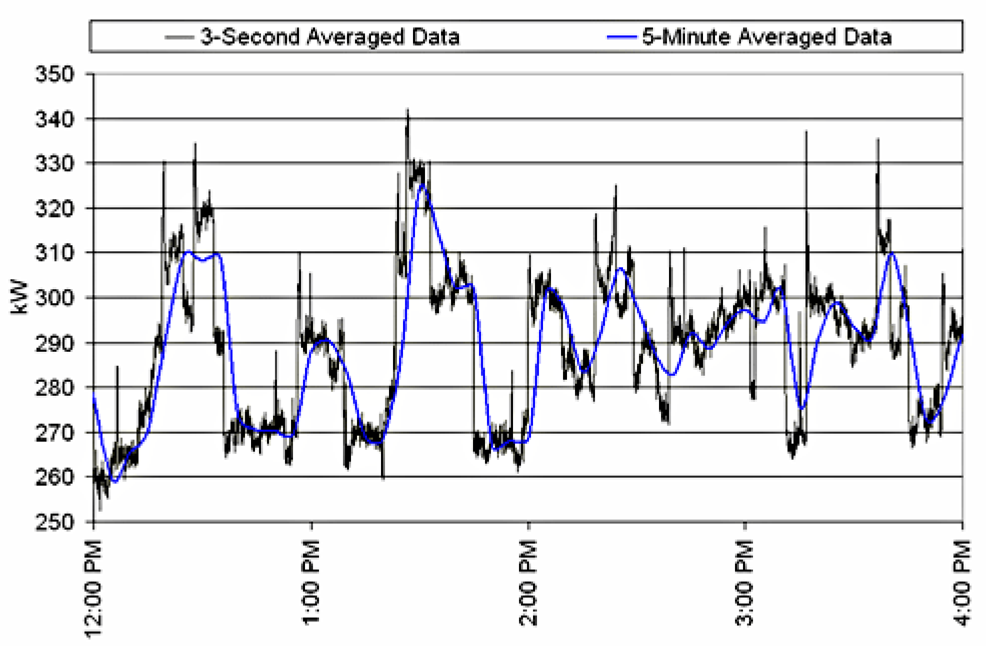
3-Second Averaged Data
5-Minute Averaged Data
kW
350
340
330
320
310
300
290
280
270
260
250
12:00 PM
1:00 PM
2:00 PM
3:00 PM
4:00 PM

DG Performance

THE DG SYSTEM MUST PROVIDE ADEQUATE LOAD FOLLOWING CAPABILITY!

- While base-load applications are much easier, both in terms of system design and economics, base-loading has two inherent problems:

1. The market is limited
2. Utility companies will continue to resist DG installations that simply remove the base-load (their “bread and butter”) and rely on the grid for peaking

Detailed dynamic models of high temperature fuel cells (HTFC) and micro turbine generators (MTG) developed at UC Irvine

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High resolution building demand data

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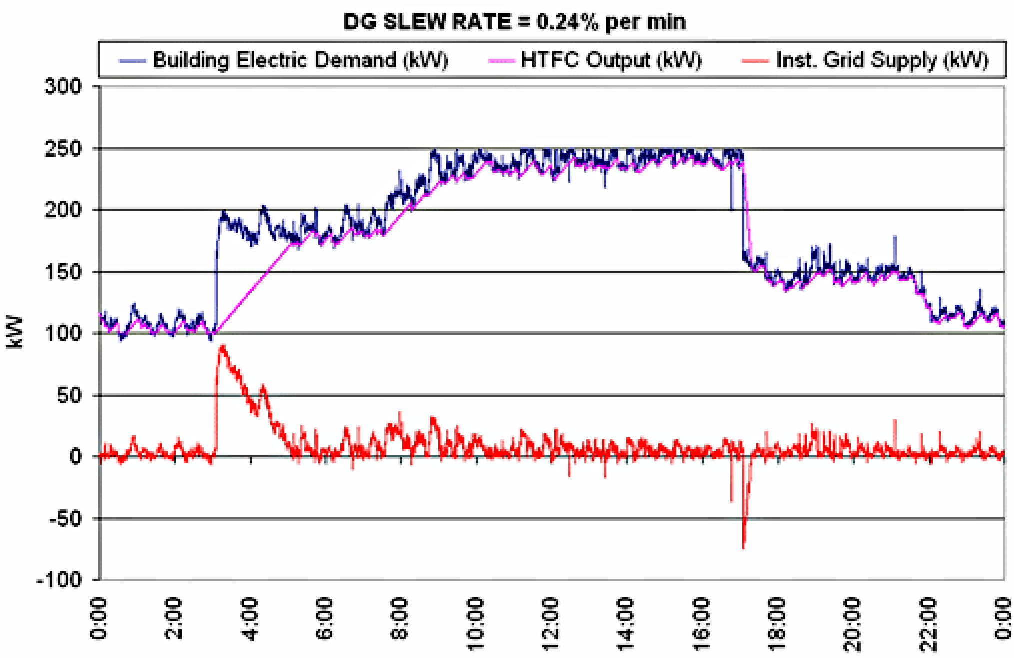
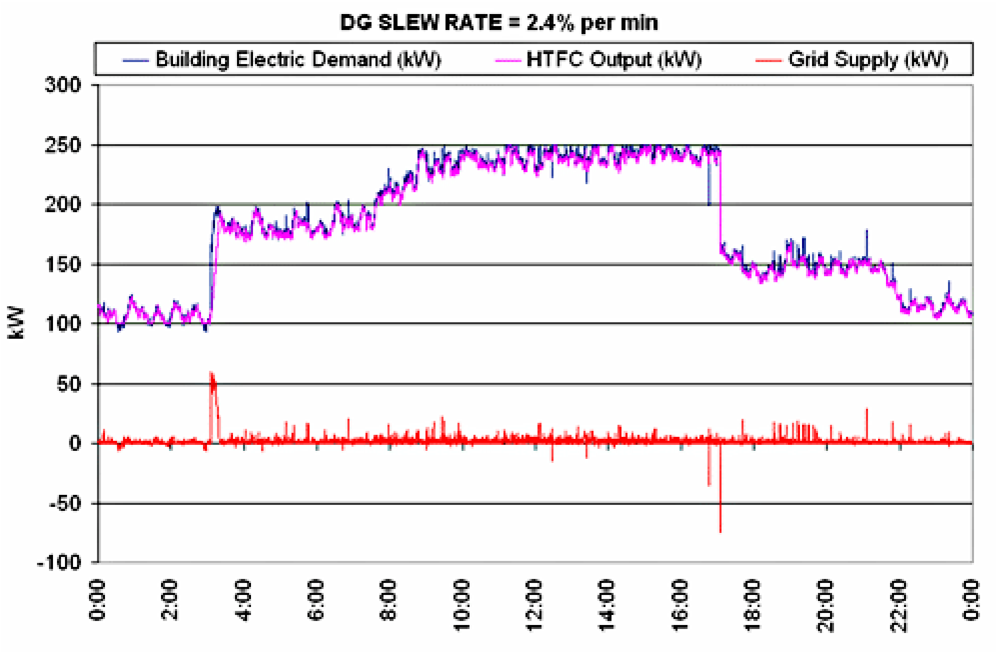
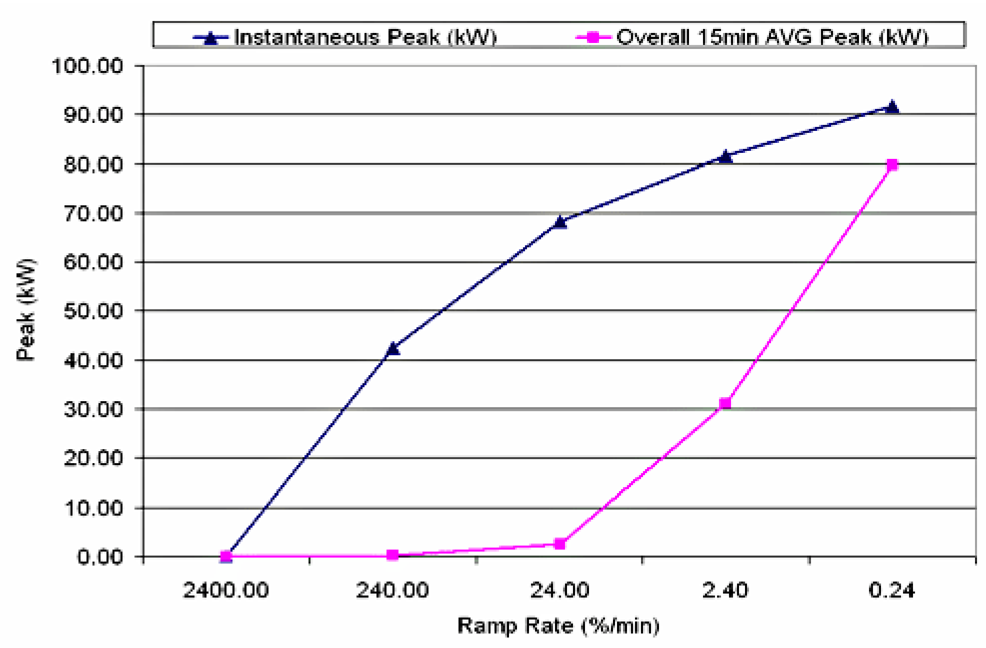
Insight into the dynamic load following requirements for DG

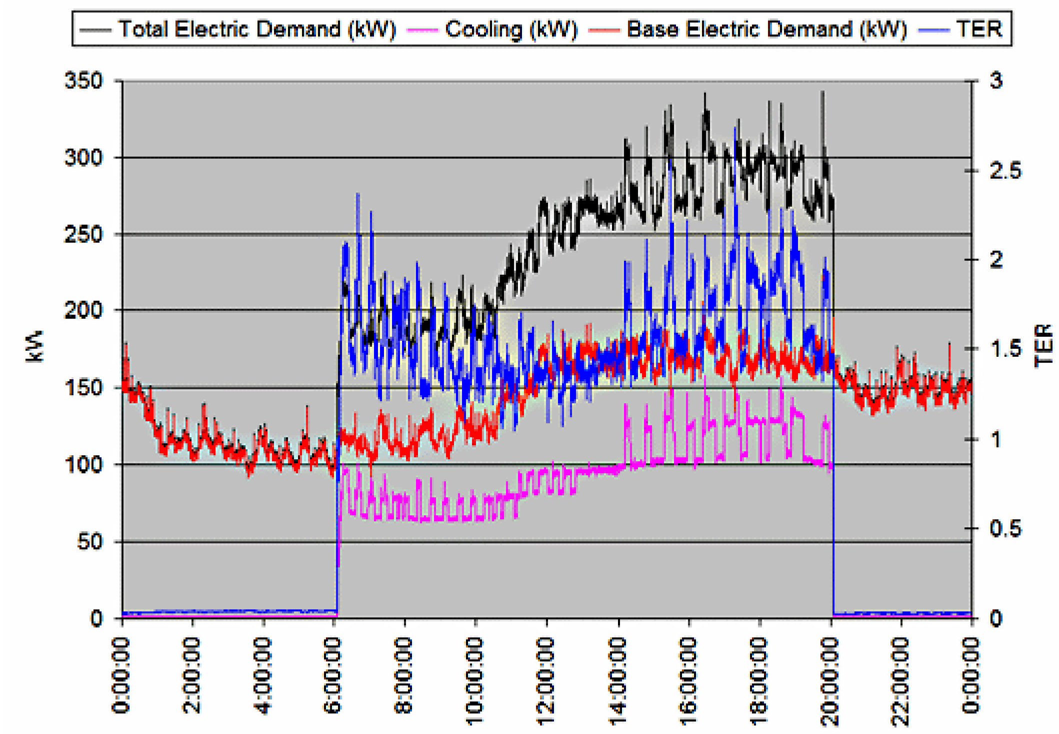


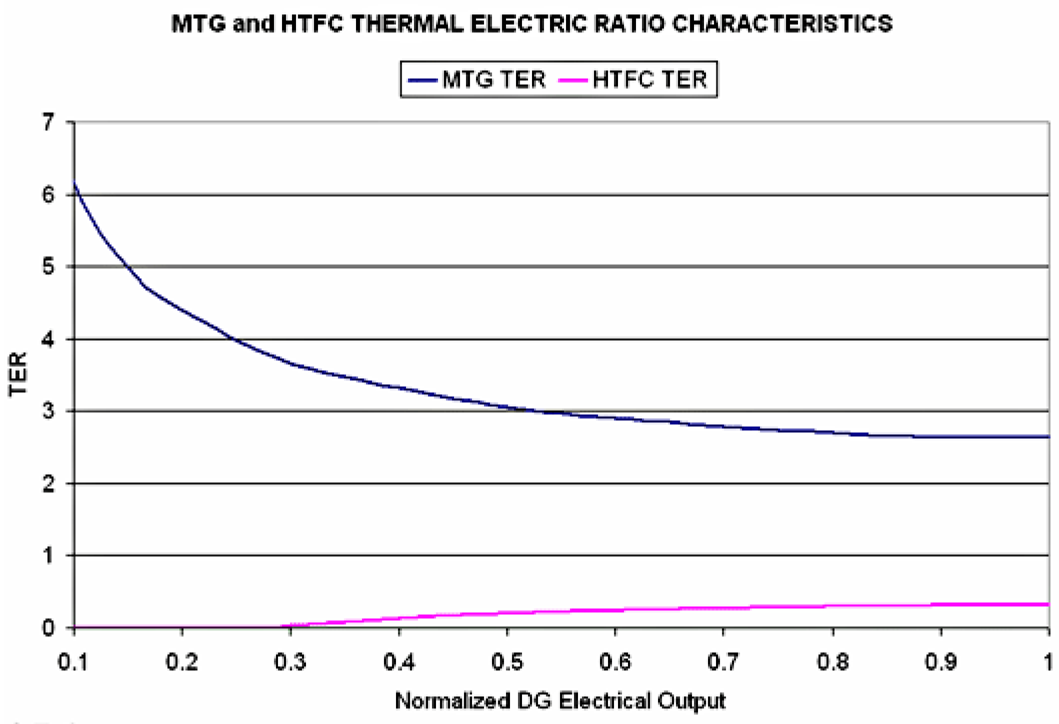




The DG-CHP System must provide the proper thermal to electric ratio!

- Again, this involves a detailed understanding of:
    1. End-use load profile
    2. The generator TER





Of course, individual DG technologies have other performance criteria that must be met:

1. Electrical efficiency
2. Lifetime
3. Degradation
4. Temperature and Altitude Derating
5. Fuel BTU Fluctuation Performance
6. Power Electronics Requirements
7. Noise
8. Emissions

NOTE: these tend to be the focus of DG technology development today

Utility Pricing

- Utility (gas and electric) costs drive the economics of DG (though power quality and reliability can contribute significantly)
- Electric utility rate schedules available to end-users can vary significantly
- DG can be used as a tool to leverage utility rate schedules for increased economic benefit to the end-user
- Natural gas pricing policies and schedules significantly affect DG benefits
- For example, critical peak pricing, power shifting, interruptible, and real-time-pricing rate schedules can be used to lower energy costs, while DG is used to mitigate the effects of the new rate schedule
- This requires detailed load analysis and simulation tools, such that the appropriate rate schedule can be chosen

Conclusions and Implications for Hybrids

Positive Implications:

Non-Technical Integration Issues

- Market Strategy – hybrid technology market timing may aid widespread adoption
- Regulatory – barriers should be low due to ultra high efficiency and low emissions
- Utility Interactions – no unique advantage

Technical Integration Issues

- System Design – By utilizing both turbines and fuel cells, hybrids have greater design flexibility for meeting end-use load demands
- Performance – Novel designs and controls can combine ultra-high electrical efficiency with the required DG system load following and TER flexibility in one package
- Utility Interactions – no unique advantage

Challenges

•Non-Technical Integration Issues

- Market Strategy – expanding the market to non-traditional DG sectors such as commercial
- Regulatory – ensuring continued incentives for advanced generation
- Utility Interactions – no unique challenge

•Technical Integration Issues

- System Design – complexity and packaging
- Performance – need novel designs and controls that combine ultra-high electrical efficiency with the required DG system load following and TER flexibility in one package
- Utility Interactions – no unique challenge

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