Strategic Role for DR in Discos – an Update

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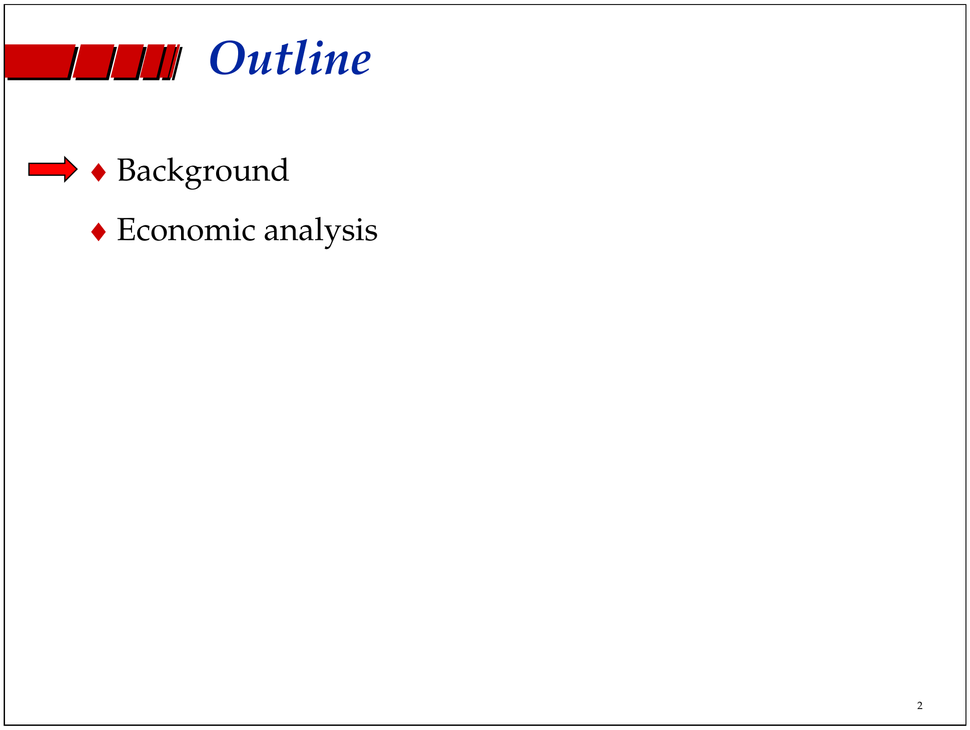
Strategic Role of DR in Distribution Systems

Stephen W. Chapel & Charles D. Feinstein

December 2000



The briefing has two main points:

1. Background--which addresses the following questions:
   - (a) Definition: What is DR?
   - (b) Motivation:
     - Why consider DR?
     - What problem does DR solve?
     - Why DR now?
   - (c) Issues:
     - What decisions are influenced by DR alternatives?
     - What issues are relevant for DR?

2. Economic Analysis--
   - (a) What are the economic consequences of DR investments?
   - (b) What is the appropriate way to measure the economic consequences

DR is interesting for several reasons.

1. It is an alternative to conventional investments, such as substations, feeders, switches, transmission lines, and central power stations. In the distribution system, DR can avoid infrastructure investments. DR provides an alternative to capacity expansion. As such, it is of interest.

2. Political considerations, possibly irrational and certainly nonanalytic, are important. (a) Deregulation is a hot topic, no matter whether it makes any sense. DR apparently fits with deregulation since it is positioned as a "small" technology that anyone can use and bypass the utility. (b) There is an uncritical belief in some quarters that new technology can solve many system problems, for any system. Some DR is new technology, such as fuel cells and PV. The environmental impacts of such new technologies are believed to be superior to conventional alternatives. (c) Technology sellers are pushing their products.

3. Economic considerations are central to the case for DR. But economic considerations may often revolve around false issues. (a) A false issue is the often-quoted utilization problem, which we address below. (b) Why economic issues are important is suggested by the macro investment level of distribution investment. The large level of distribution investment indicates that there is a great deal of capital devoted to this industry. Hence it is important to get the answer right. (c) The real issues are discussed and analyzed below.

Politics and Business

- Deregulate
  - Monopoly power
  - Scale Economies - too cheap to meter
- Belief in technology solutions
  - Computer, Internet, High Tech models
- Small (technology) is beautiful
  - Micro turbines, Fuel Cells, Solar, Wind, Engines

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Politics and Business combine to create pressures that impel decision makers to DR as a useful alternative.

1. Deregulation is a popular idea. It is ideological, but based upon three facts. (1) Apparently successful experience with telephone and airline industry. The latter is arguable, the former seems to be valid. (2) Utilities comprise an area-specific monopoly, although a regulated one. Monopoly abuses are limited by regulators. Yet, monopolies are perceived to be "bad." (3) Industry promises of falling prices, because of technology, have not been kept. The nuclear experience is an example. Champions of deregulation point to the cost of poor utility decisions borne by ratepayers that would be borne by the utility or other firm under competition. Moreover, the only way to lower costs is through mass production. But mass production requires a mass market. How will that emerge?

2. The belief that technology can solve problems or create new opportunities is based on the success of technology in transforming or creating other industries.

3. DR is attractive because it is a small scale, independent technology. The dream is to have a utility-in-a-box in the basement of a house. If we make our own heat, refrigeration, air conditioning, and hot water, why not make our own electrons? Another dream is to decrease pollution. Some DR technologies are designed to do that.

Economics & Business

- Asset utilization?
- Capital Intensity?
- Fixed & variable costs and scale economies?

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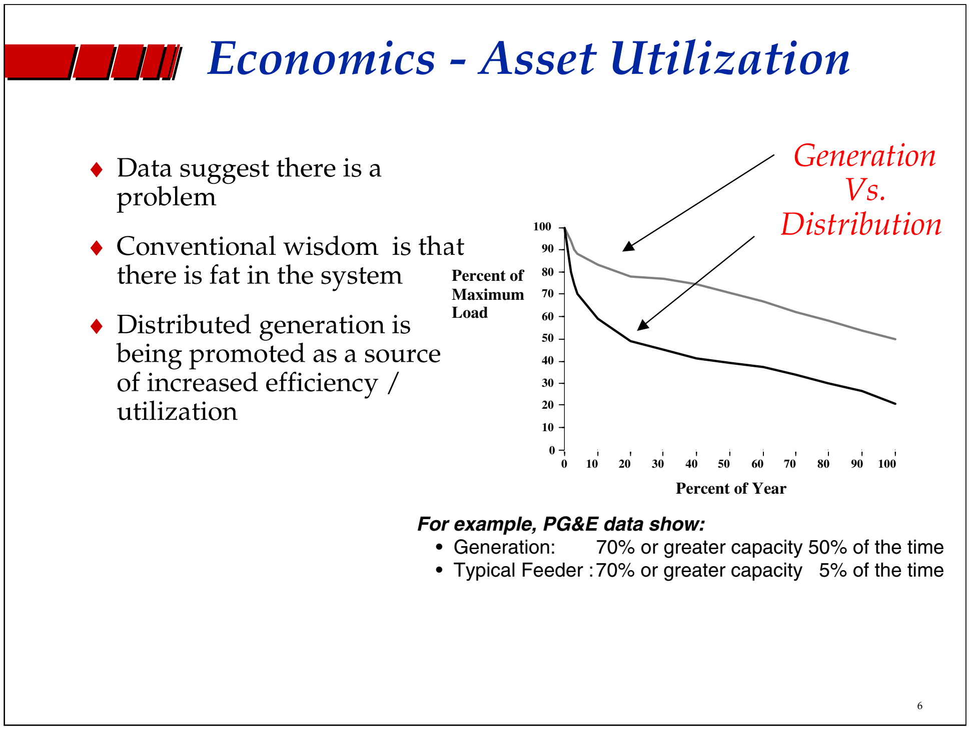
The purpose of this slide is to list the the main economic issues advanced with respect to DR.

Are these the real issues?

What does each one mean?

Why are they important?



This is a typical PG&E feeder.

The feeder is used far less than the generating plant.

The fundamental question is: So what?

Facts: The feeder is sized to meet the peak load in a local area. The plant is sized to meet the peak load in several areas. Lack of coincident peaks in the areas served by the plant creates a flatter load duration curve.

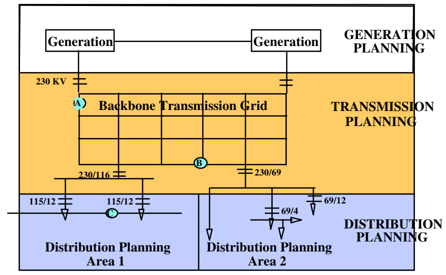
The real question is whether there is an economic opportunity because of the differences in utilization, or whether the feeder can be utilized more "efficiently" or whether the feeder can and should be replaced by something else that is a more "efficient" investment.

Despite what many people are claiming, it should be clear that efficiency by itself is meaningless. The system must perform a specific function, viz., providing electricity at peak and off-peak times, and this feeder supports that function. So we ask if there is a better way, with respect to cost, reliability, or any other criterion, to perform the function.

Indeed, it is easy to find counter examples that indicate that pursuit of increased asset utilization is neither least cost nor most reliable.

Economics - Macro Investment Levels

- 40% to 50% of electric utility net investment
- Business issues
  - Minimizing investment costs
  - Having "right" infrastructure to meet customer needs
  - Making money
- Key strategic needs
  - Managing assets
  - Linking investment decisions to customer needs



Net Invest.	
Gen.	= $8.7B
Tran.	= $4.5B
Dist.	= $13.5B
Total	= $26.7B

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This slide indicates how much money is on the table. This industry is more capital intensive than any other. $4 capital in place for $1 of annual revenue. This capital-revenue ratio means that the added value of additional capital is relatively low. Thus capital costs cannot be recovered quickly.

The business issues are not merely how much is spent on G, T, & D, but rather what customer needs are met.

There are three competing objectives: minimizing cost, meeting customer needs, and creating profit.

The objectives are achieved by creating a coherent strategy. The strategic objectives are (a) to manage assets as best as possible through investment and maintenance policies and (b) linking those management decisions to customer needs.

If (a) is pursued without considering (b), the least cost solution will not be based on anything but economic measurements. If (b) is pursued without considering (a), satisfying customer needs will not yield economically efficient solutions or profits.

This suggests the need for a methodology that balances these competing objectives.

Economics - The Real Issues

- Fixed & variable costs
- Scale economies
- Load growth
- Deferring big investments & hedging load uncertainty

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Any analysis of DR must address the real economic issues.

1. Investment alternatives are characterized by their costs, fixed (capital and operating) and variable (operating). These determine the actual cash flows. It is best to analyze these than approximate (if not fictitious) marginal costs.

2. Scale economies make for lumpy investment policies. This must be explicitly addressed and suggests that marginal considerations really do not adequately represent the actual cash flows.

3. Capacity expansion and reliability considerations are driven by load growth and demand on the system. Load is uncertain. Hence, we must address the consequences of a dynamic, uncertain variable driving decisions. Utilities have been notoriously unable to forecast this variable with any accuracy in the long term. (WPPS, NE,…)

4. The main economic benefits of DR are (a) the possibility of deferring large, lumpy investments and (b) the value of delaying an inevitable decision until the need for that decision becomes more clear.

Fixed & variable cost & scale economies

- DR is not cheaper than system energy
- As DR capacity decreases, $/kW increases
- Scale economies still matter--demand increase surprise?

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This slide discusses some economic facts.

1. It is cheaper, on a per kW or kWh basis to provide energy from the system compared with stand-alone DR. The costs of fuel cells and PV are orders of magnitude greater than conventional supply costs.

2. DR installations, such as DSM programs, exhibit increasing unit costs as it becomes more difficult to site or more expensive to achieve load reduction.

3. If demand is not forecast accurately, and DR is used to meet increasing peak load, any demand growth “surprise” cannot be met cheaply by existing capacity. The advantage of economies of scale is that they can be used to purchase excess capacity, which provides a buffer against uncertainty, relatively cheaply.

4. Nevertheless, we need to distinguish between value and cost. DR can be more expensive and still add value.

Load growth & deferral

- DR cannot always defer traditional investments
- Value of deferral related to load growth uncertainty
- DR creates value as a hedge

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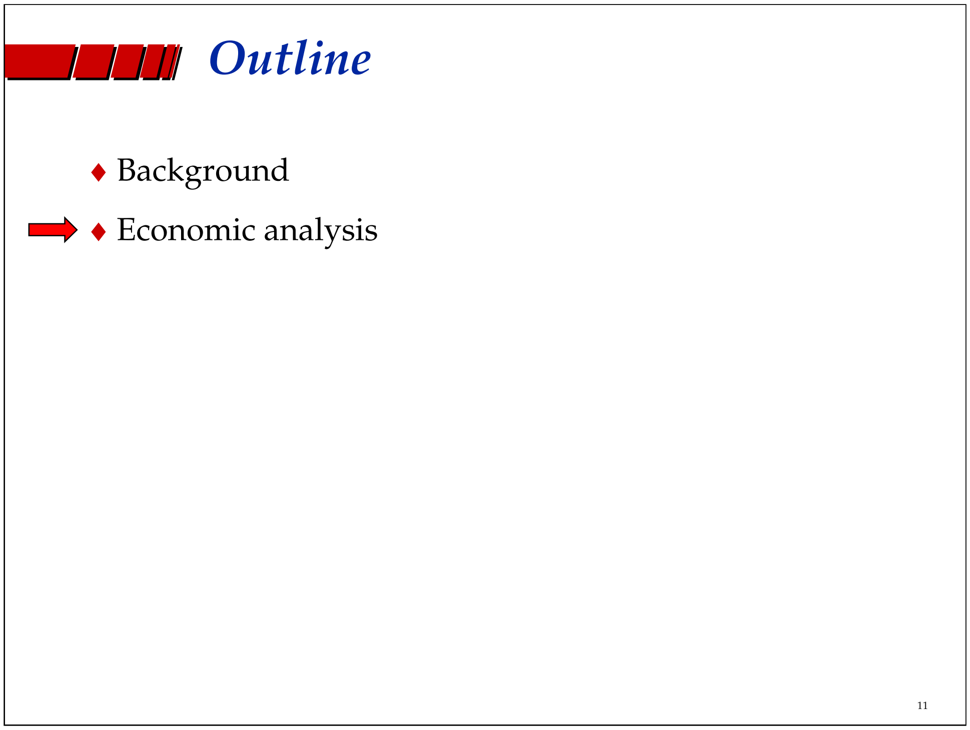
The initial motivation for DR was to defer large investments, and thus save capital costs.

This is not always beneficial.

In particular, if load growth is rapid, the amount of deferral is small and not worth the cost, in general.

Moreover, the value of deferral is related to uncertainty. If it is possible to learn more about load growth, thus reducing uncertainty, then DR can be valuable as a hedge even if load growth is *expected* to be rapid. If load growth is relatively low and uncertain, DR should have a relatively large hedge value: the large investment is deferred until the need for it becomes more certain.



Now we turn to the economic analysis of DR investments.

Objective

- Determine the conditions under which distributed resources add strategic value to distribution system capacity expansion plans

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It should be clear that some local areas are good candidates for DR, and some not. Why that is and what distinguishes between such areas is what we wish to determine in this research.

Assumptions

- DR is an investment
- DR choice based on local conditions
- DR added value:
  - integration
  - hedging
  - reliability
- DR integrated into least cost plan that meets load with sufficient reliability

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These are the fundamental assumptions of the methodology. They ought be non-objectionable.

1. The first assumption means that DR must compete with other investments.

2. The second assumption means that global or macro models cannot predict DR investments (compare with earlier Iannucci, Pupp, Hamm EPRI study).

3. The third assumption means that we will not have a list of benefits that we will add to find DR value (compare with Shugar, Rassler, El-Gasseir, and others).

4. The fourth assumption defines the objective function. Other objective functions are possible: maximize utilization, maximize customer service, maximize reliability, maximize power quality, etc. We do not focus on competing objectives. In particular, we treat reliability as a constraint such that a minimum acceptable level must be achieved. Any improvement in reliability beyond that level is expressed as improved costs or added value.

Approach

- The Area Investment Strategy Model identifies the least cost capacity expansion plan for a distribution planning area
- Problem is represented by several collections of data
  - Investment alternatives, specified with respect to capacity and costs
  - A local planning area, described with respect to load level, load shape, and uncertain load growth dynamics
  - Other parameters, including the cost of emissions, the cost of unserved energy, and the reliability of service
  - Values are selected based on available data found in the literature or provided by member utilities.
- Two kinds of local areas are defined, transmission constrained areas and infrastructure constrained.
- The strategic value of distributed resources is measured with respect to their inclusion in the least cost plans for each area.

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1. The first point identifies the model used in the analysis.

2. The second point describes the range of the data inputs. The details are found in the user's manual for the model. The purpose of this point is to indicate that the model requires a robust, yet readily available, data set.

3. This point highlights the special assumptions made in this study: there are two kinds of areas, based on constraints. These areas are what we found in real utilities.

4. Fundamental idea: find the optimal strategy. If DR is in it, DR adds value. If not, DR does not add value. This responds to basic idea of strategy model. Typical DR analysis defers existing strategy, which need not measure the true value of DR. This analysis finds the best strategy, hence the value of DR.

Data and modeling assumptions

- Basic planning data
  - T=15 years, r=.06
- Load growth specifications
  - Initial peak load=100MW
  - Sets of 3 annual growth rates: slow set ($\leq$.03), moderate set (<.05), rapid set ($\leq$.10)
- Load shape
  - Load duration curve=PGE feeder (above)
- Investment alternatives
  - T=large transmission upgrade, 50 MW, $300/kW, 40 year lifetime
  - S=new substation, 20 MVA, $200/kW, 40 year lifetime
  - modS=modular substation, 10MVA, $250/kW, 40 year lifetime

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1. T is the planning period and f is the inflation adjusted discount rate. It is selected so that it is long enough to permit the policy to play out. DR adds value over time as a contingent investment.

2. The study investigates effect of load growth and load growth uncertainty on DR value.

3. Investment alternatives are based on actual experience.

Data and modeling assumptions--cont'd

- Investment alternatives (cont'd)
  - SDR=salvageable DR (similar to DSM)
    - six sequential alternatives
    - 2.5 MW each
    - increasing capital costs: $500/kW, $750/kW, $1000/kW, …, $2500/kW
    - 15 year lifetime
  - DG=distributed generation, not salvageable
    - unlimited number available
    - 2.5 MW each
    - capital cost=$500/kW
    - 20 year lifetime

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SDR looks like DSM, exhibits increasing marginal capital cost.

DG is a peaker.

Salvageable vs. nonsalvageable is an important idea. We analyze these separately in order to contrast economic consequences--salvageable assets avoid future rents upon retirement. The perfect hedge is salvageable.

Data and modeling assumptions-cont'd

- Operating Costs
  - Fixed O&M=0.5% of capital cost for all alternatives
  - Variable O&M: T=S=modS=$.05/kWh, SDR=$0, DG=$.07/kWh
  - Emissions: T=S=modS=$.0025/kWh, SDR=$0, DG=$.0025/kWh
- Losses and unserved energy--to measure how DR improves reliability
  - Outage time: T=S=modS=0.25hr/1000hr
  - Unserved energy cost = $7/kWh
  - SDR & DG --> UE cost reduction=50%
  - Losses = 0
- Terminal value
  - Salvage value of capacity = $21.79/kW-yr

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1. Operating costs are taken from literature and utility experience.

2. Losses are taken from other reports. Unserved energy from other reports. Unserved energy reduction by SDR and DG is completely arbitrary--no data.

3. The terminal value is the value we assign to capital remaining in the system at the end of the planning period. The terminal value is based on $300/kW capital cost, discounted at 6% over 30 years.

Results - Transmission Constrained Areas

- Distributed resources are strategically valuable in local areas that are transmission constrained.
- The value of distributed resources decreases as the local area peak load growth rate increases.
- Distributed resources provide benefit by deferring the need for the large capital investment in transmission capacity.
- Distributed resources provide benefit whether they are load-following or not and whether they are salavageable or not.

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In transmission constrained areas, the main benefit is deferral. The value of the benefit can be as much as approximately 50%.

The hedge benefits are virtually non-existent.

Results - Distribution Infrastructure Constrained Areas

- The infrastructure constrained area has limited strategic need for distributed resources.
- The value of distributed resources decreases as the local area peak load growth rate increases.
- The distributed resources provide benefit by deferring the need for the traditional infrastructure capacity investments and not by eliminating the need for the investments.
- In an infrastructure constrained area, distributed resources provide benefit if they are load-following and salvageable. Non-salvageable distributed resources do not provide measurable strategic benefits under the assumptions made in this study.

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There is very little benefit for DR in distribution infrastructure constrained areas.

The costs are such that deferral benefits are minimal.

When benefits occur, they are hedge benefits, and typically used to hedge a downstream investment. But the investments do indeed occur and the DR investments are salvaged. Hence the deferral is only temporary, which contradicts a fundamental claim made by DR proponents. That is, one of the strong claims made for DR is that it will replace other infrastructure investments. Unless the costs change greatly, this is not likely to happen. Investments may be deferred, but not displaced.

Results - Infrastructure Constrained Areas (cont'd)

- Non-salvageable distributed resources with very low operating costs may have some strategic value in infrastructure constrained areas
- If it is possible to reduce the uncertainty in forecasting future load growth based on observations of past load growth, then the strategic value of distributed resources increases.
- Reducing the capital cost ($/kW) of non-salvageable distributed resources is critical for such resources to play a strategic role in infrastructure constrained local areas.

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The cost structure of DR investments is currently not competitive with traditional distribution infrastructure investments.

Reducing the capital cost ($/kW) of non-salvageable distributed resources is critical for such resources to play a strategic role in infrastructure constrained local areas.

Bottom line: Given current costs, in infrastructure constrained areas, build infrastructure.

These results are documented in *Strategic Role of Distributed Resources in Distribution Systems*, TR-114095, EPRI Final Report, November 1999. The input file for this analysis is available from the authors.

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