# Intro to DER

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# DER vs DG

- DG = Distributed Generation
- DER = DG + Storage

May seem like semantics but small storage grew in potential since 2005

# What is in DER

- Definitions vary but Small ($<$ 49MW) generation seems to count with $<$ 1MW most common.
  - Plenty of renewable
  - Small turbine
  - Backup generators
  - Battery banks.
- Combined Heat and Power
  - Steam Generation
  - Chill Water
  - District Energy

# Why Would I (Private) Build It?

- Power Quality
  - Equipment is sensitive to voltage drops or spikes
  - Equipment is sensitive to frequency variation.
  - Wave shape and harmonics
  - High reactive power needs (Often avoids utility charge.)
- Reliability (Often combined with quality)
  - High cost of interrupted power, e.g., hospital
  - Two common measures
    - System Average Interruption Duration Index (SAIDI), average total time without power over a year.
    - Customer Average Interruption Duration Index (CAIDI), average time without given your power is out.
    - Many more relating to frequency and cost of lost service.
  - You could have lower rates if you have an interruptible tariff.

# Why Would I (Private) Build It? (Cont)

- Peak reduction
  - If you have demand (kW) charges, your maximum use.
  - If you have a coincident peak (kW) charge, you use at system peak.
- Cogeneration Opportunity
  - Already need Steam or Chill water
  - Electricity generation is a bonus
- Reduction in volumetric (kWh) charges
  - Net metering just a bit to shave off the high block charges
  - Peak Pricing Tariff
  - Real-time Prices.
  - Nice subsidy.
  - Actually, social cost, cheaper.
- The utility side is significantly more complicated.

# Why The Controvoursy

- Limited markets for local reactive power.
- Limited markets for local reliability.

# Three simple ways of thinking about costs

- The Make vs Buy trade-off (TC).
- The Minimum Efficient Scale (AC), i.e., volume such that AC is at a minimum.
- Investment Delay, a time value of money concept.

With all cost estimates the key conceptual problem is to only look at incremental costs.

- It is often unclear what those incremental costs are relative to.
- Cost does depend on your point of view.

# Example Make vs Buy

- Assume cost functions of $C = F + \alpha q$ form.
  - Fixed cost
  - Constant average variable cost
- Make vs Buy: Given known q, Choose the least cost technology

# Example MES

- Several definitions of MES
  - Quantity such that $MC = AC$.
  - Quantity such that AC decreases very little as quantity increases.

# Example Investment Delay

- Pushing costs into the future can be valuable.
- Value of delay increases as interest rates increase.
- Exponential discounting $P = \frac{F}{(1+i)^N}$.
- Example: Maintenance expenditures of \$100 a year forever. What is the value of skipping a year?
  - $PW(Maintance) = \frac{100}{i}$ At i = 10% this is 1000.
  - Delay for 1 year is $\frac{\frac{100}{i}}{1+i}$. This is 909.09.
  - The difference is the savings.

# Report Example

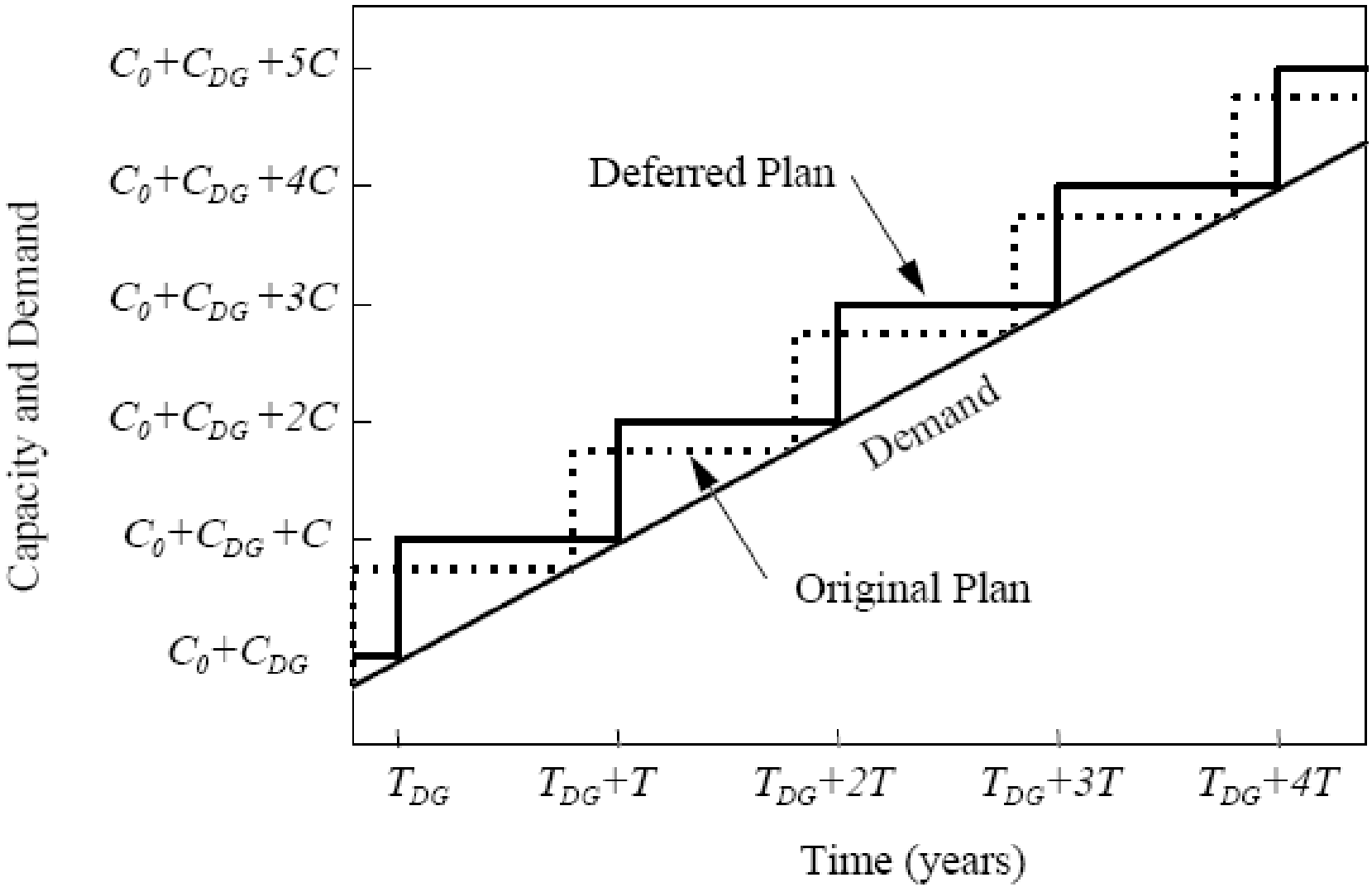


Figure 1:

# How Did We Get to the Current G-T-D Arrangment (MES Argument)

- Both large scale and small scale originally existed.
- Large scale developed
  - Lower AC
  - Higher MES
  - Speed of change up till 60s made this the dominant form.
- Small scale continued to develop
  - Right sized scale and MES
  - Decreasing AC
  - 1978 Qualifying Facilities Era was when they could sell power under some conditions.

# Private Choice of Technology (Make vs Buy Argument)

- Have access to utility power and DG.
- Several States of Opportunity Costs
  - If you have no special needs and need to pay full cost of fuel.
  - If you have 'Free' access to fuel, e.g., wood chips, AC of DG is lower.
  - If power quality or interruption is not what is desired, AC of utility power is higher.
  - If you face a Peek, Time of Use or Demand Charge.
  - More complicated diagrams can be made but this works.

# Utility Point of View

Please note that lots of power quality issues need to be solved on the D side, with capacitors and transformers. Power quality may actually get worse with new equipment and DG.

- Utility: Supply customer needs with T+G or with DG. Trade-offs between the two in an isoquant/isocost sense.
- Customer: Decide to take utility solution or provide with private DG. (Make vs Buy).

# Odd Diagrams and Points in the Report

# Fig 3-4

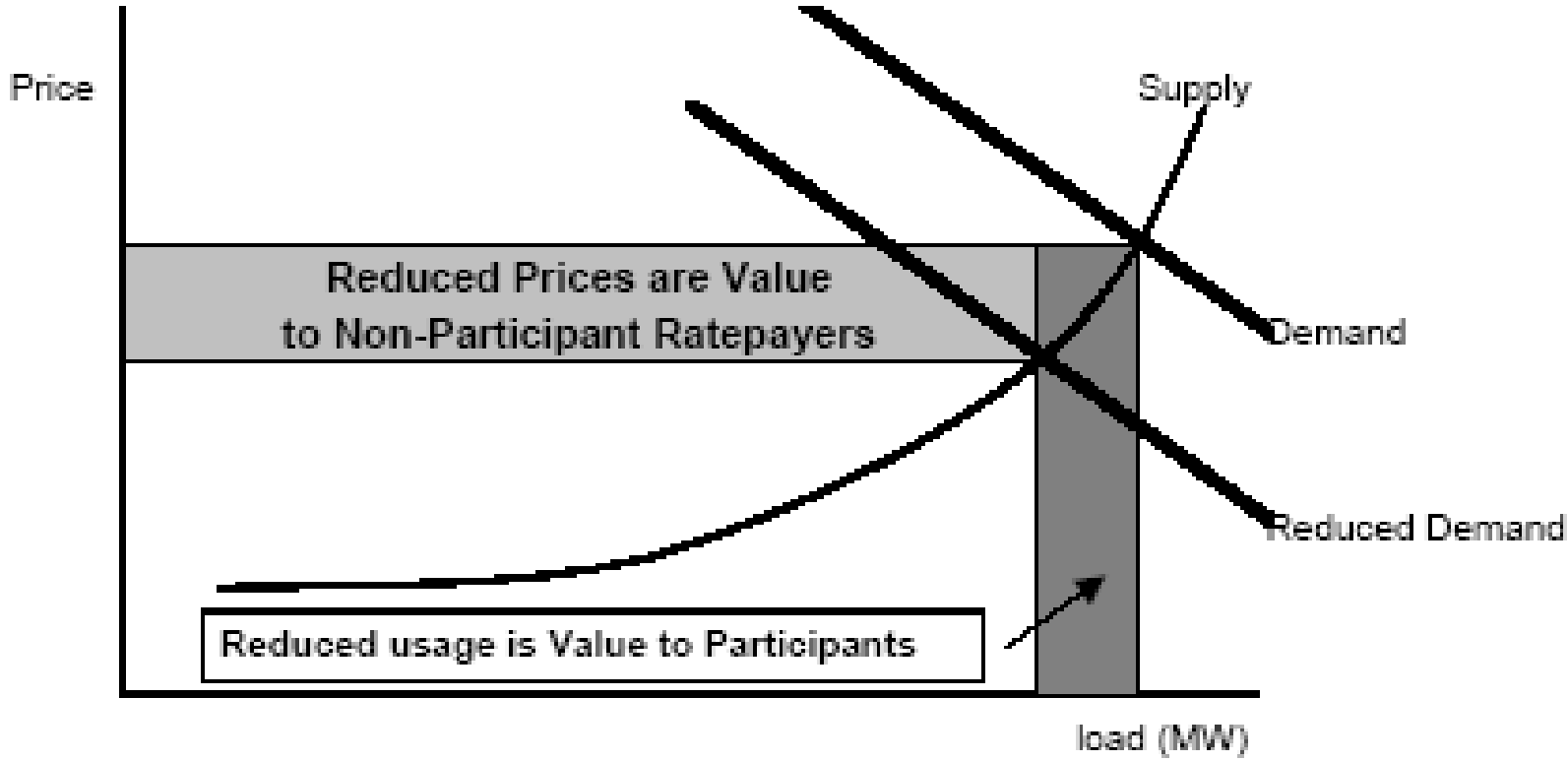


Figure 2:

# What is Wrong?

- Need two diagrams, one for constrained DG and one for wholesale electricity market
- Confuses Reduced usage is Value to Participants with utility cost reductions and reduction in DWL.

# Fig 3-7

- Gives perfect competition result for a competitive public utility.
- Somehow, it can be rate of return regulated.
- Analysis should be that of a price ceiling with a reduction in demand and a reduction in the ceiling.