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

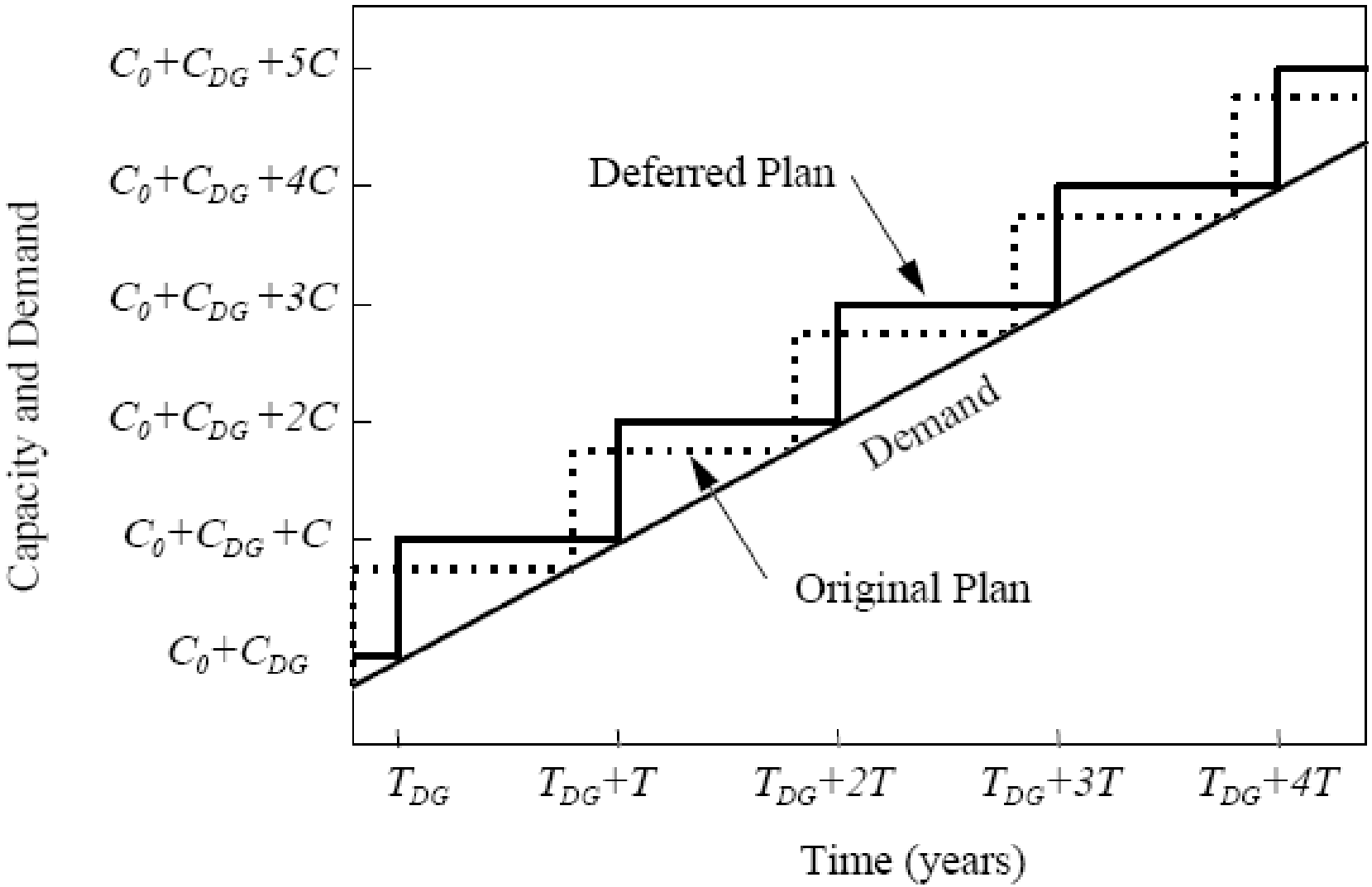

Figure 1:

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

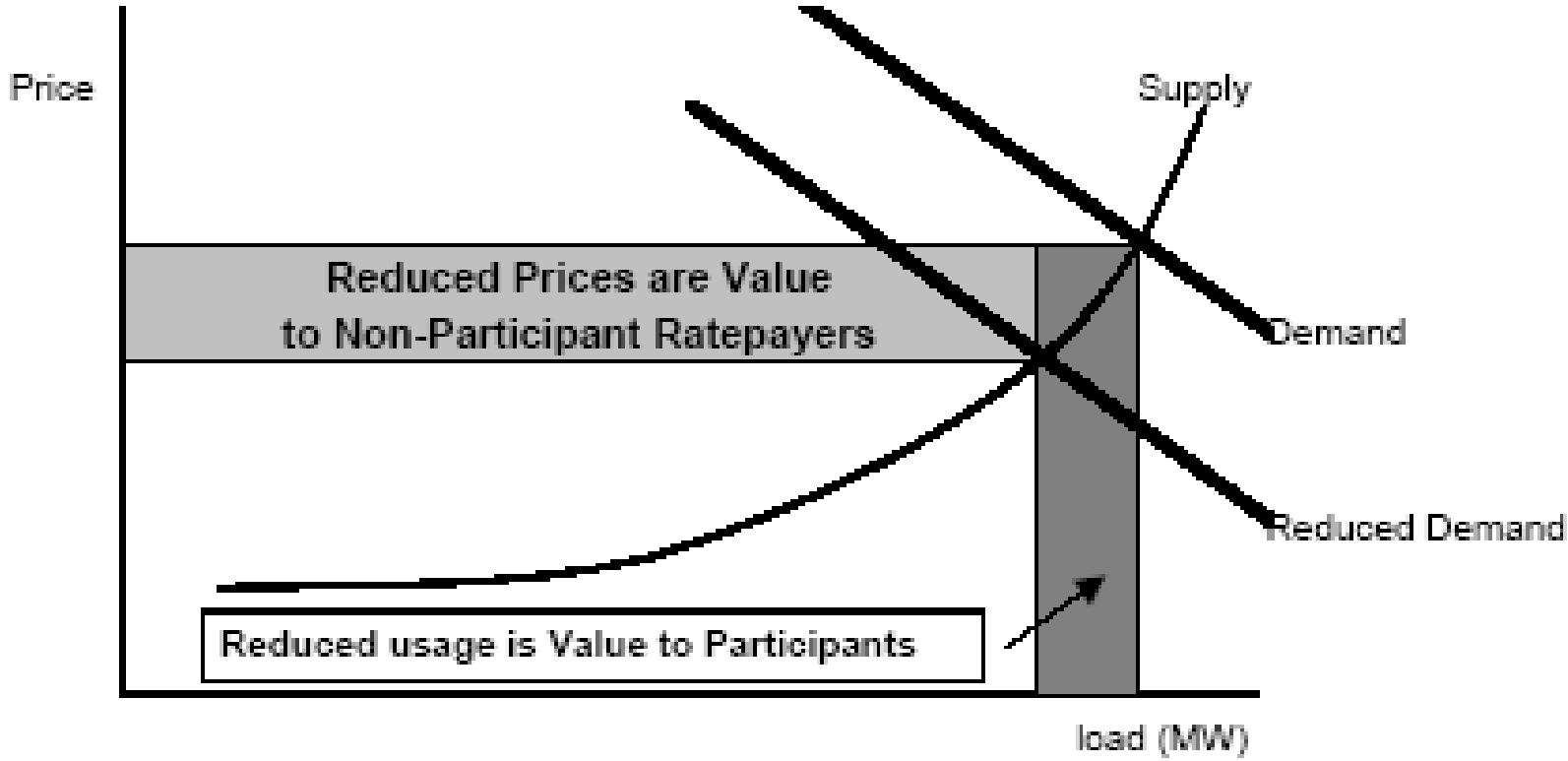

Figure 2:

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.

What is going on NOW

By NOW I mean in the last month/week. Comments are rough because it is all very new.

- Proposed rule for virtual power plants, though not by that name, as well as new definitions so DER can participate at the wholesale level. (Nov 17, 2016)
  - `https://www.ferc.gov/whats-new/comm-meet/2016/111716/E-1.pdf`
  - CAISO has had them for a few years `http://www.caiso.com/Documents/Non-GeneratorResourceRegulationEnergyManagementImplement pdf`
- New York is on the topic too. (Oct 27th, 2016) `http://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId={59B620E6-87C4-4C80-8BEC-E15BB6E0545E}`

The FERC NOPR is *very* political

- Appears timed to be in place before the FERC board turnover in January.
- There is a procedure for rule making that involves months of notice and hearings.
- Undoing requires doing this again.

The FERC Proposal

- Elimination of Barriers to Electric Storage Resource Participation in Organized Wholesale Electric Markets.
- Participation of Distributed Energy Resource Aggregator in the Organized Wholesale Electric Markets

The Barriers

Please note that many market definitions vary by ISO/RTO. FERC gives directions.

- Rules are set up to accommodate existing technology:
  - How long they can provide service
  - How they provide service
  - Often restricted to regulation service
- Examples
  - ISO-NE requires registered Generator Assets to participate in all wholesale markets
  - Common vision of storage is pumped storage with under an hour use.
- Some RTO/ISOs are better
  - PJM Energy Storage Resource Model
  - CAISO Energy Storage Resource model
- But all are found wanting by their *own* assessment.

Connection to Demand Response

Demand response is typically:

- Things done on the consumer side of the meter
- Remote turn of of equipment
- Agreements to turn off with notice
- Getting paid for not consuming electricity

The reason is that demand response is considered a residual definition, if not generation then demand response.

Virtual Power Plants, aka, Aggregators

- Typically there is a minimum size to participate in the wholesale markets. Minimum size is defined by the unit.
- Aggregation allows you to combine many small units and operate them as one large unit.
- Common practice
  - Banks are savings aggregator
  - Corporations are investment aggregators to accommodate small investments.

The FERC Proposal

- Electric storage resources must be eligible to provide all capacity, energy and ancillary services that they are technically capable of providing in the organized wholesale electric markets;
- The bidding parameters incorporated in the participation model must reflect and account for the physical and operational characteristics of electric storage resources;
- Electric storage resources can be dispatched and can set the wholesale market clearing price as both a wholesale seller and a wholesale buyer consistent with existing rules that govern when a resource can set the wholesale price;
- The minimum size requirement for electric storage resources to participate in the organized wholesale electric markets must not exceed 100 kW; and
- The sale of energy from the organized wholesale electric markets to an electric storage resource that the resource then resells back to those markets must be at the wholesale LMP.

Commentary Bidding Parameters

- Not just about storage. This is aiming for technology neutrality.
- Bidding parameters could include things like state of charge
  - Like CAISO and NYISO.
  - MISO is more detailed requiring hourly max levels, storage rates,etc.
- Proposal is: "RTOs/ISOs establish state of charge, upper charge limit, lower charge limit, maximum energy charge rate, and maximum energy discharge rate"

Commentary (Con't)

- Balance between the additional costs and complexity to the ISO/RTOs and the benefits of technological development
  - Makes it harder to manage the grid.
    - NG that has connection to pipeline and backup diesel is easier to optimize than battery with limited storage.
    - It literally increases the mathematical difficulty and will require new models. Basically, convert to pumped storage model.
  - May produce "Gresham's law"" power with increased market monitoring costs.
  - New technology does not get developed unless there is a way for it to make money.
- Spinning Reserves requires spinning, but batteries don't spin.

Commentary, Buyer and Seller

- Some existing limitations
  - MISO in real-time market but as demand response
  - NYISO as negative prices on generation side with other restrictions.
- This is a proposal to submit bids as both a buyer and a seller in the same period.
  - Makes sense since this is a special feature of storage but;
  - ENRON did some manipulation of congestion pricing with this. They did it through wheeling but there may be a dynamic analog.

Commentary on size

- Smaller than *most* ISO/RTO, CAISO is low with 10kW
- 100kW puts high-end Teslas on the list.
- 100kWh Powerpack, at $145K, with $52K inverter buys in.
- Most DER is under this but with the aggregation rules, may not be an issue.

No Arbitrage Rule or is it?

- Avoids people buying at wholesale and then net metering.
  - I bet there is a way around this!
  - But they used the distribution network to get the power.
- Need new rules for a firewall between the retail and wholesale markets.
  - Can I buy wholesale (G+T) to avoid retail (G+T+D)?

This will be where the next round of trouble will be. How will the load serving entity, i.e., the utility survive?

Aggregation, Virtual Power Plants

- Idea
  - Get a bunch of small DER together.
  - Contract to control market interactions subject to limitations.
  - Pay them for their power/storage
  - Take a slice.
- CAISO idea as far as I can tell but others have done it.
  - Was usually just demand response, i.e., getting paid for not using power.
  - NYISO puts limitations on the size of the individual units, less than 10kW.
- Would allow more behind the meter storage, think PV to participate, but currently many limitations on them injecting power.

Why this is really interesting.

- LMP don't often provide the right incentives for new generation.
  - Prices are high now but
  - Once you enter, prices would be low.
- This allow you to build a power plant for an area a bit at a time.
- May offset some smart grid costs, the generator pays rather than the Load Serving Entity.
- Connects with making the nodes as broad as possible to increase competition.

Unsaid but Developing Elsewhere

- Plenty of proposals for reactive power compensation. CAISO is looking at this https://www.caiso.com/Documents/StrawProposal_ReactivePowerRequirements_FinancialCompensation.pdf
- May help compensate DER.
  - Inverters can have problems providing reactive power without providing real power.
  - May be a place for the D side to operate, reactive power provision and managment.
- UK has Enhanced Reactive Power Services" http://www2.nationalgrid.com/uk/services/balancing-services/reactive-power-services/enhanced-reactive-power-service/
  - Compensates those that can provide reactive power