U.S. Department of Energy

WORKSHOP ON VALUATION OF BENEFITS AND COSTS OF DISTRIBUTED GENERATION

Estimating the Costs and Benefits of Energy from Distributed Energy Technologies (DETs)

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Presentation overview

- **Definition of energy value and potential overlap with other values**
- **Methods used to estimate energy value**
- **Fundamental issues:**
  - Developing profiles for DET resources
  - Accounting for changes in marginal units (and curtailment) with time, DET penetration, or footprint
  - Fuel cost projections and uncertainty
- **Overlap with other value categories:**
  - Separating energy value from capacity value and integration costs
  - Accounting for compliance cost impacts
  - Wholesale price reduction effects

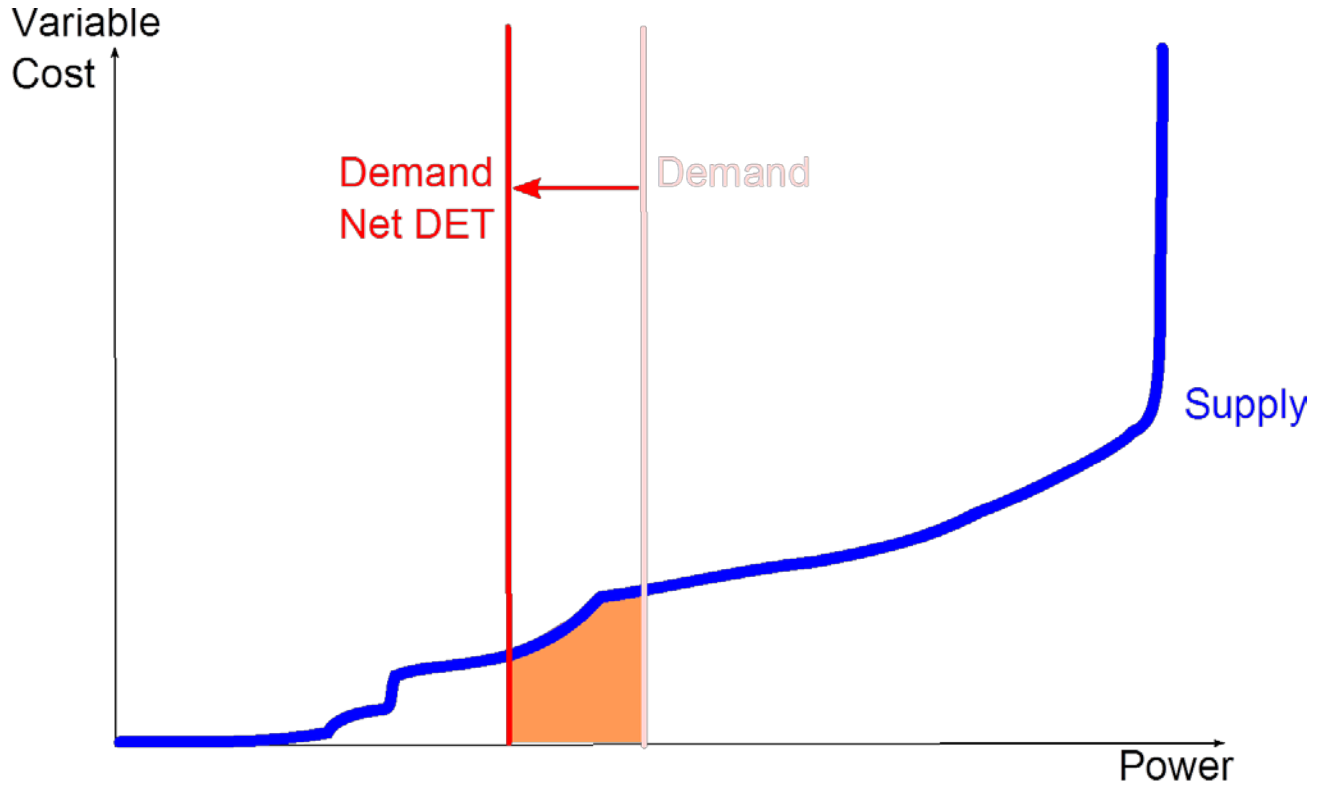
What is energy value, and what is included for the purpose of this presentation?

Definition: How much are power-system variable costs reduced (or increased) due to DETs

Cost category	Included?	Overlapping Session
Fuel and variable O&M	☑	
Curtailment	☑	
Energy losses	⊘	Avoided T&D (Fine)
Capacity	O	Value of Generation Capacity (Margolis)
Balancing/cycling/integration	O	Grid Services (Imhoff)
Compliance cost impacts	O	Social Costs and Benefits (Hoskins)
Risk hedge value	O	
Wholesale price reduction	O	

☑ Focus of this session
⊘ Not included in this session
O Discuss potential overlap in this session

Understanding energy value

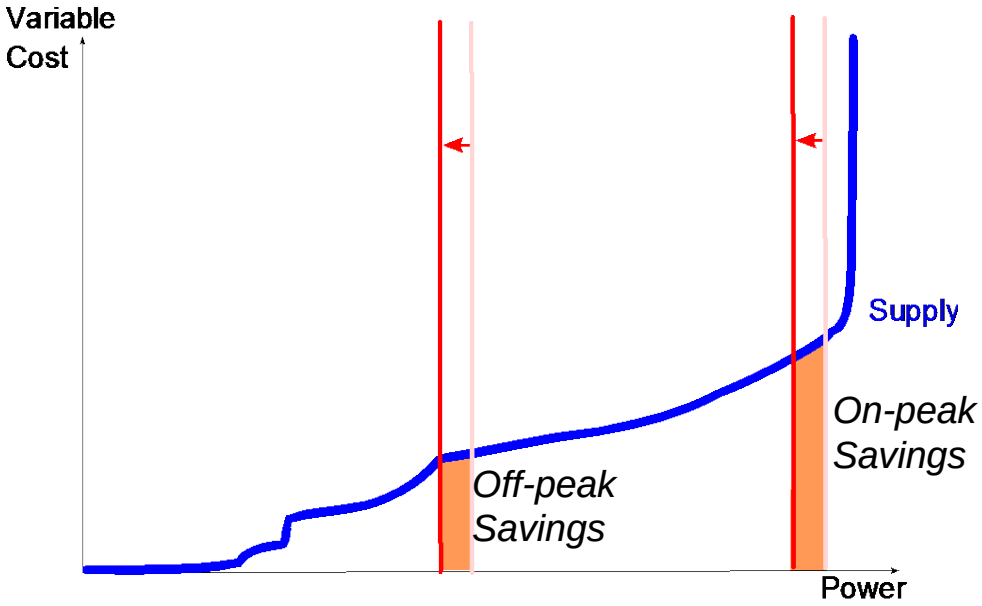


- **Power systems are generally dispatched to minimize variable costs**
- **Dispatch plants up to the point that demand is met (marginal unit)**
- **Addition of DET reduces generation, which reduces variable costs**
- **With large DET share, increasingly lower cost units are displaced**
- **Complications: (1) some DETs shift electricity use (DR), or increase it (storage, EVs); (2) power system constraints can lead to curtailment**

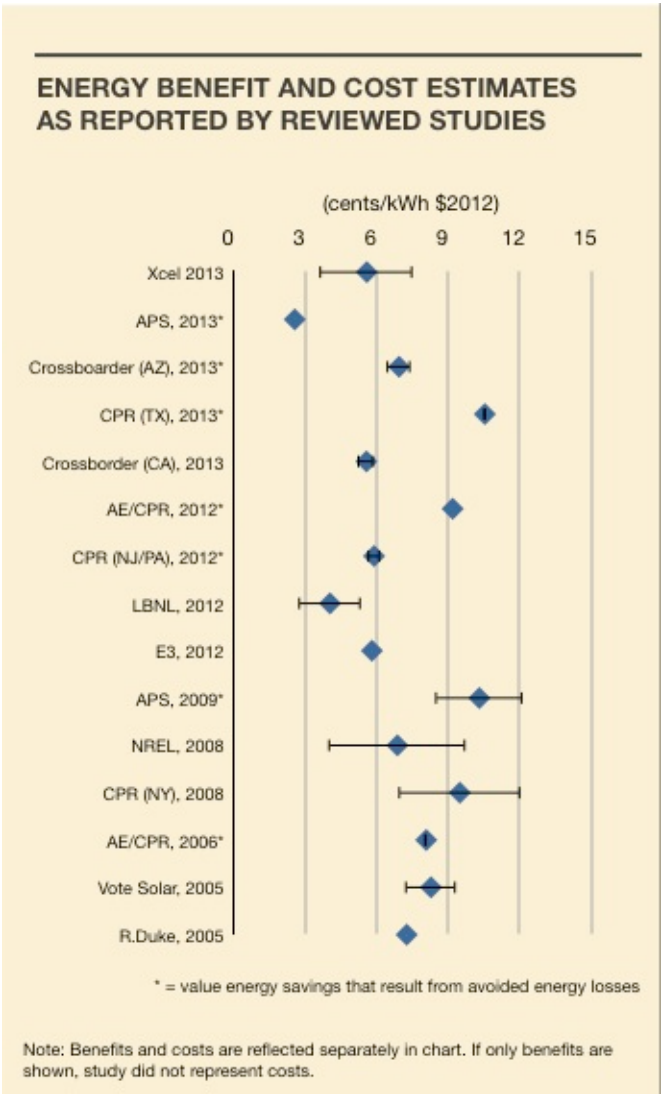
Methods

Three main questions / steps:

1. When is DET generating (or charging)?
2. What generation is displaced (or used) during those times (i.e. what is the marginal unit)?
   - Can all DET generation be used or is there a need for some curtailment?
3. What are the variable costs of the displaced generators?



Energy Value of DPV from RMI Study:

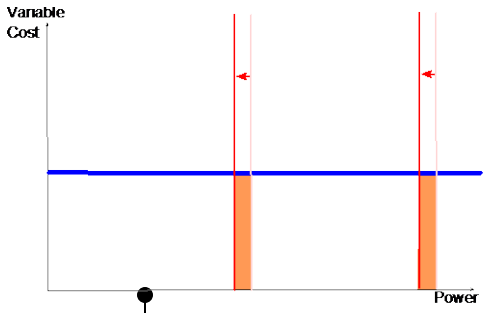


Step #1: When is DET generating (or charging)?

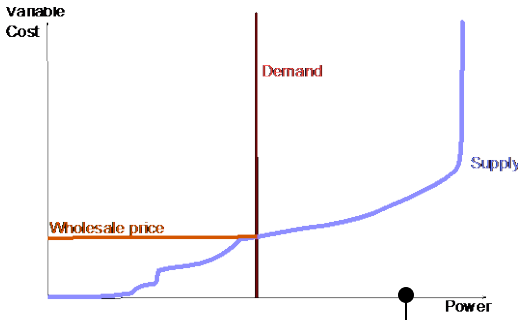
- **Solar PV or distributed wind**
  - Relatively straightforward to use historical meteorological data with location, type, size, and orientation of DET
- **Demand response**
  - Programs often designed to reduce demand during peak times
  - Does customer time-shift energy consumption (e.g. pre-cooling)? Is there a rebound (increase in energy post-event)?
- **Electric vehicles**
  - Customer preferences & infrastructure will dictate charging needs/availability
- **Customer-sited storage**
  - Is storage dispatched based on local retail rates?
  - Or is it dispatched based on local T&D needs?
  - Or is it dispatched based on bulk power system needs?
- **Combined heat and power (CHP)**
  - What processes drive dispatch of CHP units? Is it building/district heating? Industrial process? Do bulk power system needs impact dispatch?

Step #2: What generation is displaced (or used) and at what heat rate?

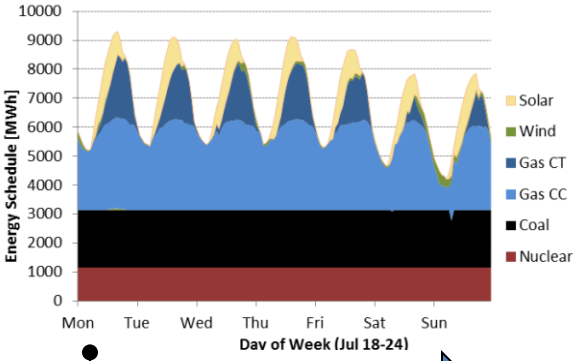
One type of unit always on the margin



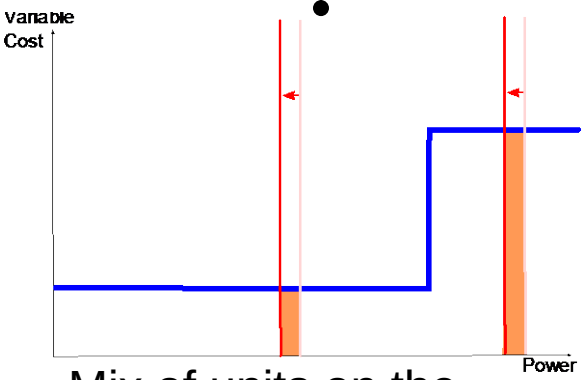
Historical marginal plant: wholesale prices, system lambdas, econometric methods



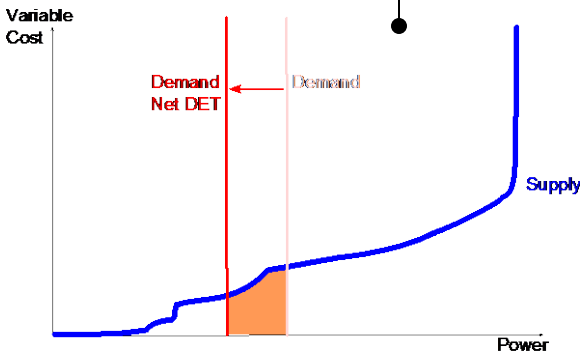
Production cost model: *static generation mix*



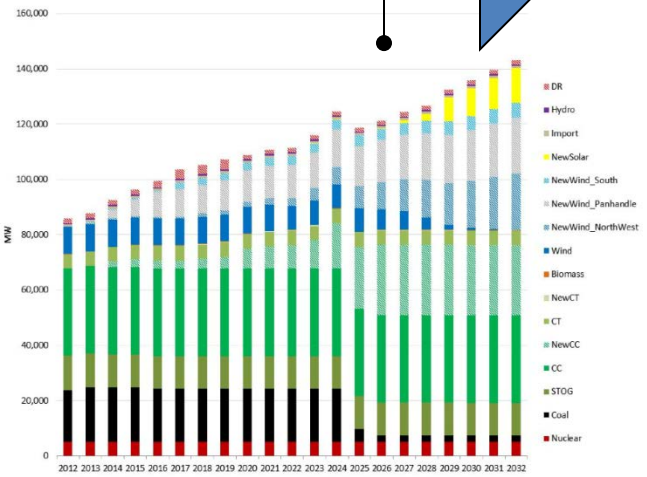
Increasing complexity of analysis



Mix of units on the margin, e.g. off-peak CCGT, on-peak CT



Simple merit-order dispatch



Production cost model: *dynamic generation mix*

Step #2b: Can all DET generation be used or is there a need for some curtailment?

- **When the system is constrained, DET may need to be curtailed rather than displacing generation**
  - Curtailed DET does not reduce variable costs
- **Curtailment mostly occurs with low load and high shares of DET generation, and is magnified by:**
  - Congestion: transmission and distribution constraints
  - Inflexibility in conventional generation: high startup and shut-down costs, long start times or minimum run times, high minimum generation levels for reliability or environmental reasons (e.g. minimum river flows for hydro)
- **Only some of the previous methods can endogenously estimate curtailment needs**

Step #3: What are the variable costs of marginal units?

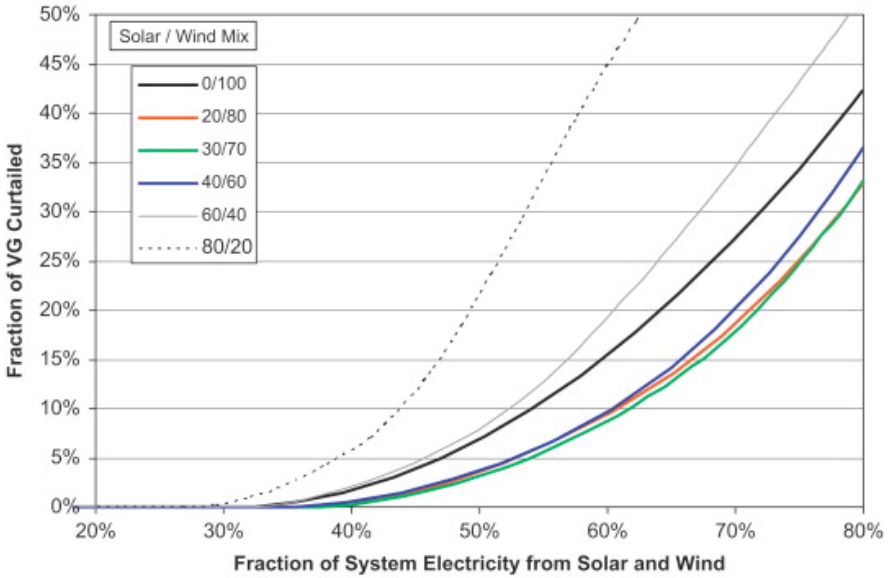
- **Variable O&M costs are relatively small: can use data from EIA or others**
- **Fuel costs are large source of uncertainty and variation in estimates of energy value**
- **Estimates of energy value need to project variable costs over life of DET**
- **NYMEX futures and EIA AEO are common sources of fuel price forecasts**

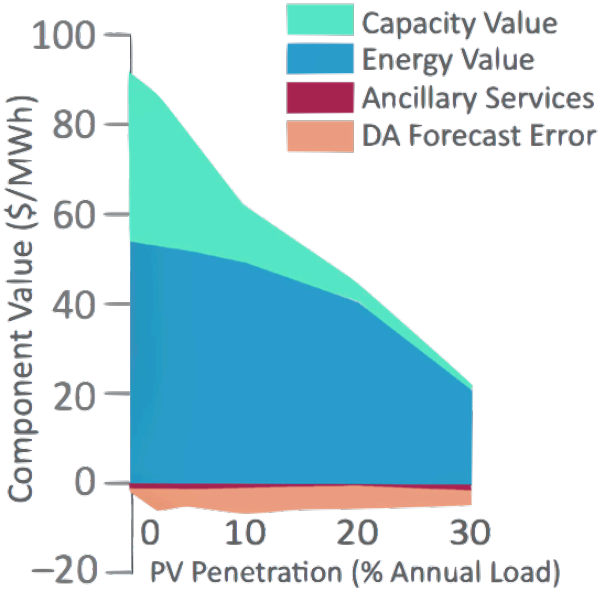
Fundamental Issue #1: DET Output Profiles

- **Not a lot of experience and data for certain types of DETs**
  - Solar and wind are among the most straight-forward
  - DR, electric vehicles, storage, CHP all more complicated
- **Different assumptions for dispatch/availability can be both justifiable and lead to quite different results**
  - e.g. different energy value if you assume storage will be dispatched to reduce customer peak demand charge vs. to minimize system costs
- **Dispatch of DET can depend on penetration of other DET**
  - e.g. storage dispatch to minimize system costs will be different with low PV vs. with high PV
- **Only some of the methods for identifying marginal units can account for different / complicated DET profiles**
  - Particularly important for net energy consuming technologies (e.g. storage, electric vehicles), and for DETs that can be dispatched

Fundamental Issue #2: Change in marginal units (& curtailment) with time, DET penetration, or footprint of analysis

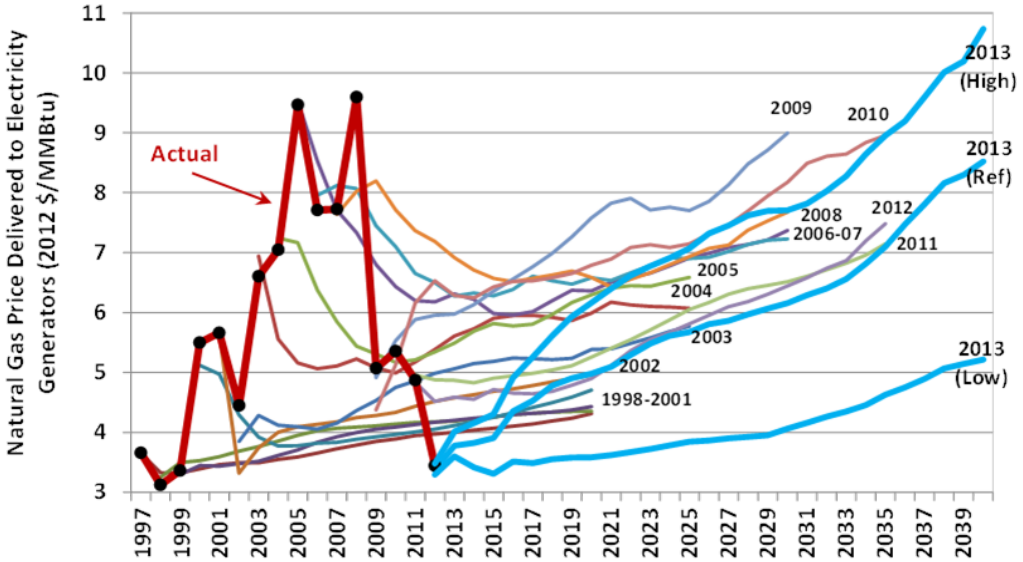
- **Which units are on the margin depends on time, DET penetration, and interactions with neighboring regions; also affects curtailment**
- **Only some methods for estimating which units are displaced endogenously account for these changes, otherwise adjustments need to be made 'manually'**
- **Changes in marginal unit and curtailment with DET penetration can be important factors at high penetration, but have often been ignored in studies thus far**





Fundamental Issue #3: Fuel cost projections and uncertainty

- **Future fuel costs are uncertain – how is this addressed?**
- **Fuel costs vary by location and season – will these differences be the same in the future or do they reflect temporary constraints?**
- **Lack of fuel costs for some DETs implies overall exposure to fuel price volatility will be decreased (risk "hedge" value)**
  - Is this a social benefit? Or does it only inure to the participant? How can it be calculated?



Overlap Issue #1: Separating energy value from capacity value and integration costs

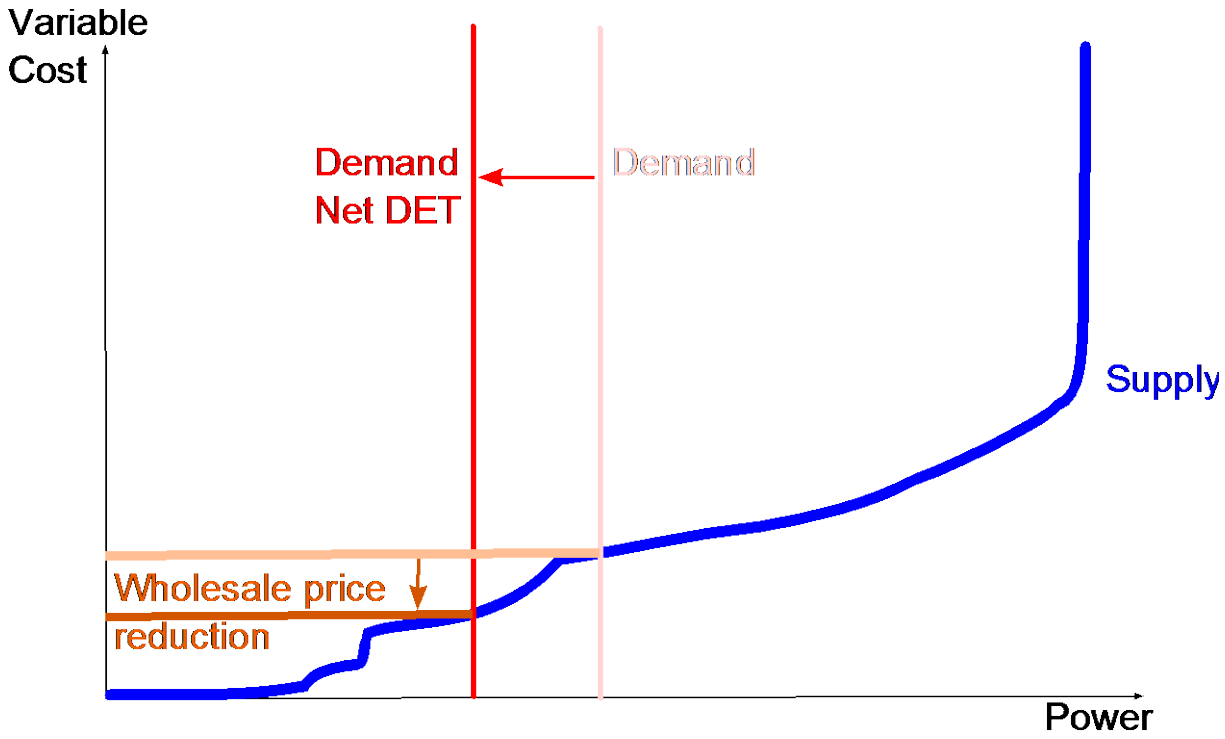
- **When wholesale prices are used to estimate energy value, one needs to be careful not to "double count" capacity value**
  - Wholesale prices can sometimes exceed variable costs of generators (scarcity prices)
  - High prices in the energy market may reduce capacity market prices
- **To some degree wholesale prices and production cost models embed costs associated with "integration"**
  - Part-load heat rates and startup costs are often included in production cost models
  - Wholesale prices may reflect opportunity costs related to shutdown or ramping
  - Again this requires careful consideration of what costs and benefits are included and in what category

Overlap Issue #2: Accounting for compliance cost savings

- **Wholesale prices, system lambdas, and production cost models may already include costs associated with criteria pollutants (e.g. NOx or SOx permit prices)**
  - Be careful not to double count with social costs, but also recognize that permit prices may not reflect true social cost
- **RPS compliance cost savings**
  - DETs can sometimes reduce retail sales, which reduces absolute amount of renewable energy needed to meet RPS based on fraction of retail sales
  - Some DETs may also produce RECs that count toward RPS compliance, thereby offsetting alternative REC purchases
- **GHG compliance cost savings**
  - Some DETs may help meet current or future GHG goals or regulations
- **These values can be considered part of energy value, can be considered part of social costs and benefits, or might be considered separately altogether**

Overlap Issue #3: Wholesale electricity price reduction ("merit-order") effects

- **Addition of DET can lower wholesale power prices**
- **Clear benefit to consumers that purchase power in wholesale markets, but…**
  - Is this a social benefit or just a transfer from producers to consumers?
  - How long does this effect persist? Is it permanent or temporary?



Summary of Key Points

- **Three steps to address energy value:**
  - When is DET generating (or charging)?
  - What generation is displaced (or used) during those times?
    - Does any of the DET need to be curtailed instead of used to displace generation?
  - What are the variable costs of those generators?
- **Fundamental issues in answering these questions:**
  - Developing profiles for DET resources
  - Dependence of marginal units and curtailment on time, DET penetration, and footprint of analysis
  - Fuel cost projections and uncertainty
- **Overlap with other categories**
  - Separating energy value from capacity value and integration costs
  - Accounting for compliance cost savings
  - Wholesale price reduction effects