



# Solar Photo-Voltaics: Economies of Scale (Phase I)

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November 2013



## Phase I: Solar-PV economies of scale

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- Questions:
  - Are there important economies of scale in solar-PV?
  - Will existing economies of scale stay the same or change as PV technologies and supply-chains gain experience?
  - Do existing policies distort PV markets in unintended or undesirable ways because only some system types or sizes are favored?
  - Given limited funds for PV financial incentives, what policy types and program designs and features will best achieve public policy goals, while minimizing any negative spin-off effects?



## Research to date . . .

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- PV business models are determined in part by complex interactions among:
  - federal, state, and local government policies and incentives;
  - utility rates and tariffs and other rules and regulations; and
  - other institutional practices, especially among financial institutions.
- Policies sometimes differentiate by system size:
  - financial and tax incentives
  - interconnection standards
  - resource portfolio standards
  - utility rates and tariffs



## PV LCOE studies

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- Three different purposes:
  - ① technology comparisons and grid parity
    - ✦ solar versus coal, gas, nuclear
    - ✦ utility-scale versus rooftop
  - ② investment analyses
    - ✦ breakeven and ROI for specific opportunities and business models
    - ✦ understand production costs and compare to retail utility rates or to wholesale prices or PPAs
  - ③ Modeling future cost reductions
    - ✦ where are the best opportunities and how big are they?



## PV LCOE studies

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- Different questions asked and answered:
  - What regions or service territories are included in the analysis?
    - ✦ market maturity and competition?
    - ✦ insolation values?
    - ✦ location-specific utility rates and tariffs, financial incentives
  - What vintage(s) of system costs are used?
  - Are financial incentives and subsidies included?
  - Are interconnection, T&D, and grid integration costs included?
    - ✦ If yes, are they specific or generic?
  - Are environmental and social costs and benefits considered?
  - Are sensitivity analyses reported?



# Factors influencing economies of scale

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- **Modules**
  - Subject to “Swanson’s Law” which states that each doubling of cumulative production of PV cells yields a 20% lower LCOE, through manufacturing learning-curve effects and economies of scale and through technology improvements
- **Balance of system hardware**
  - including site preparation and mounting systems, power electronics gear including inverters, switches and wiring
- **Soft costs**
  - including marketing, customer acquisition, siting, permitting, regulatory and contractual applications and transactions, insurance, and property taxes

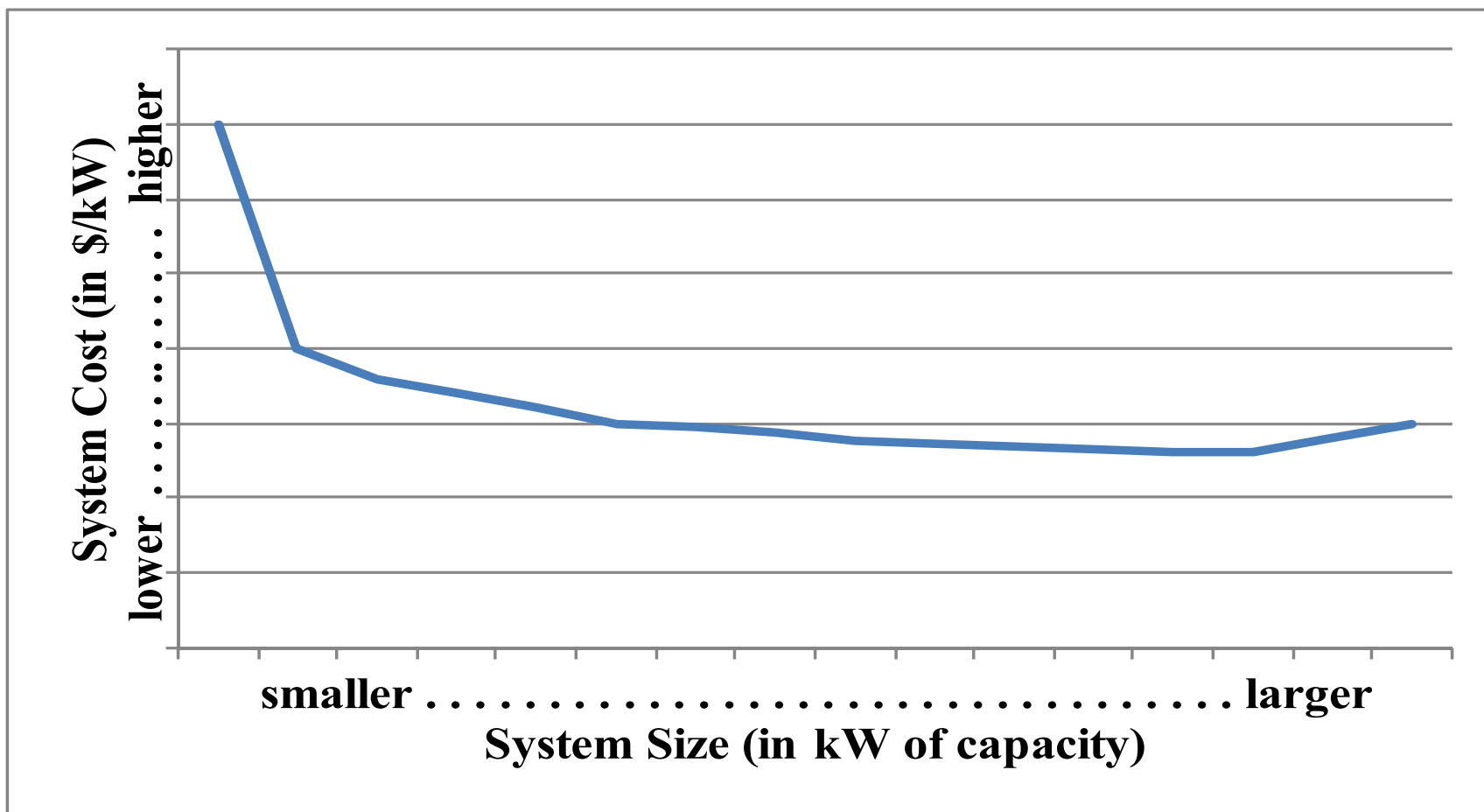


## Different approaches to lower-cost PV

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- **Build systems larger**
  - Get better pricing by purchasing modules and BOS hardware in bulk
  - Many soft costs do not increase in a linear manner with size
  - The trend is that larger systems have lower per-unit soft costs, because soft costs can be amortized over more kW and kWh
- **Standardize systems, including small systems**
  - The goal is to achieve equal bulk-purchasing benefits by aggregating purchases of modular and standardized units
  - Soft costs are being reduced by many means, e.g., aggregated purchasing, community solar, solar-ready subdivisions, streamlined siting, permitting, interconnections

# General trends observed in PV EOS studies



Source: Author's construct illustration, based on general observations from all reviewed studies.





## Final/Phase II (Feb. 2014)

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- Detailed comparisons of PV LCOE studies
  - Which studies include which factors?
  - How to assumptions affect the outcomes?
  - How might policy makers use the information from all three types of LCOE studies?
- Detailed review of state PV policies
  - How do state policies influence system size?
  - How might policies be changed so that policy supports will affect all system sizes more equally?