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Models to inform technological development: Examples from energy storage, electric vehicles, and solar energy

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Models to quantify technology performance targets, measure progress, inform priorities

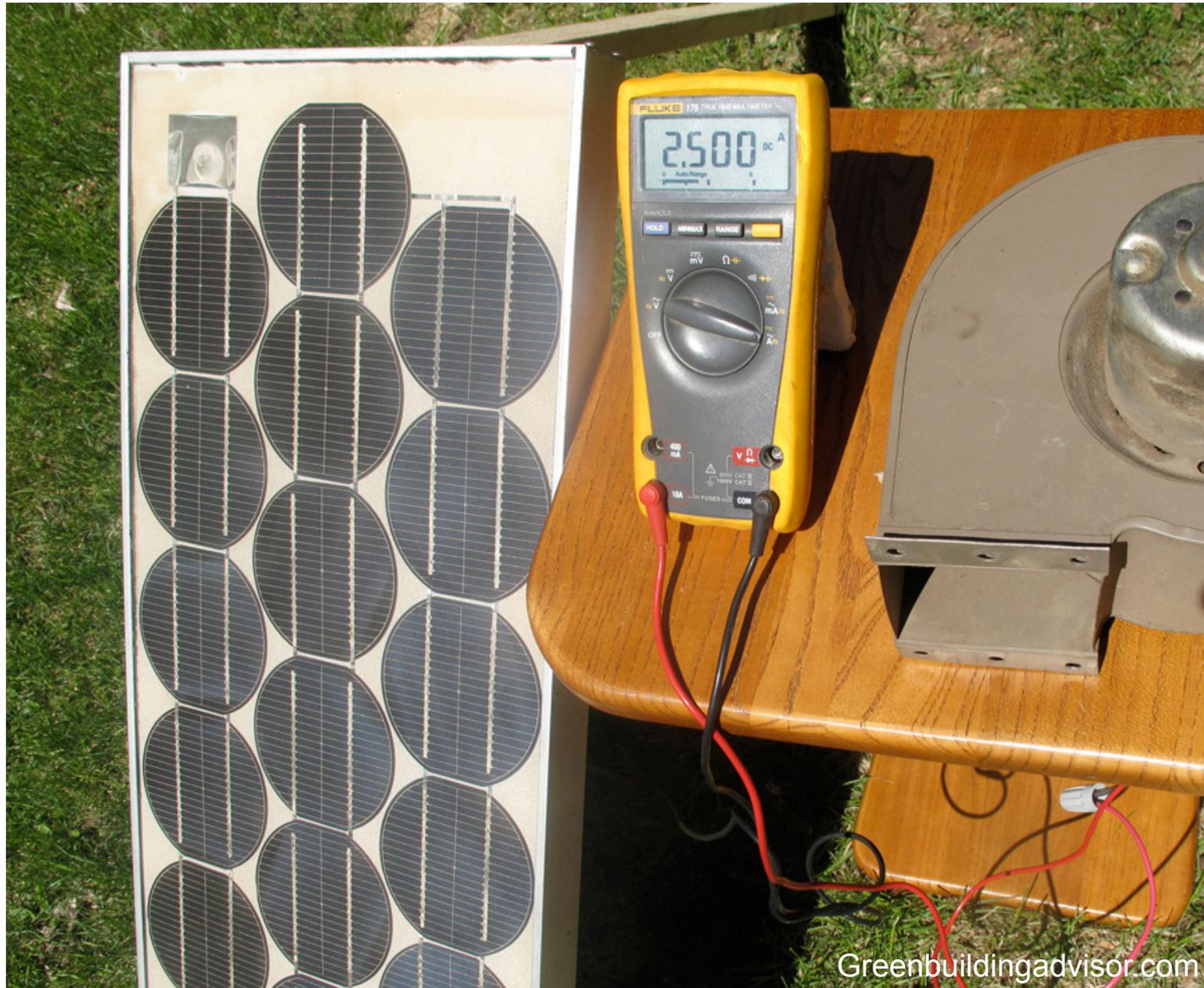
Examples from:

- Stationary energy storage
- Batteries, charging infrastructure for electric vehicles
- Solar energy

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- Stationary energy storage
 - Batteries, charging infrastructure for electric vehicles
 - Solar energy
- ➔ Models can guide experimentation, increase success rate of investments in new technologies



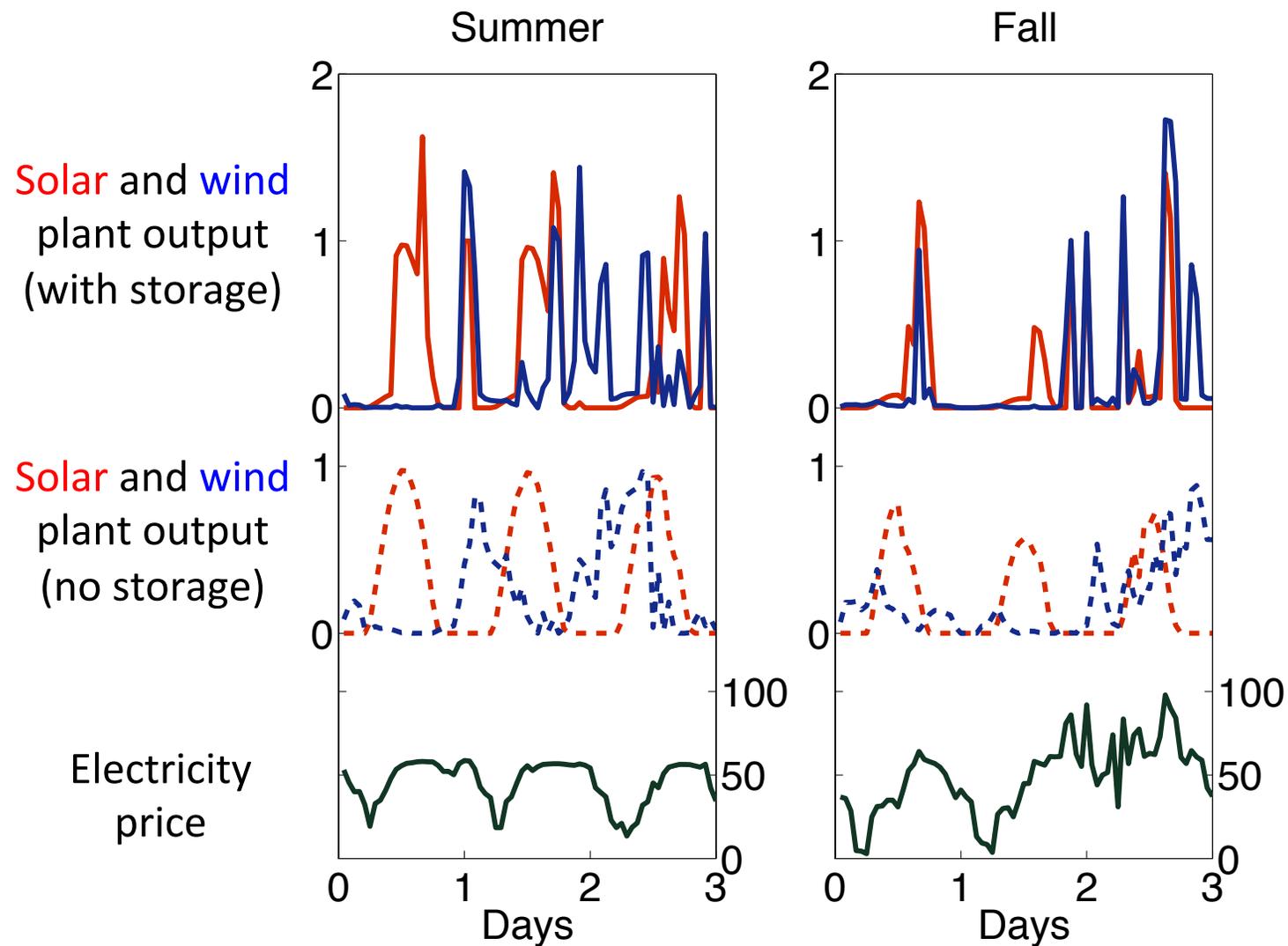
Solar (photovoltaic) panel from the 80s



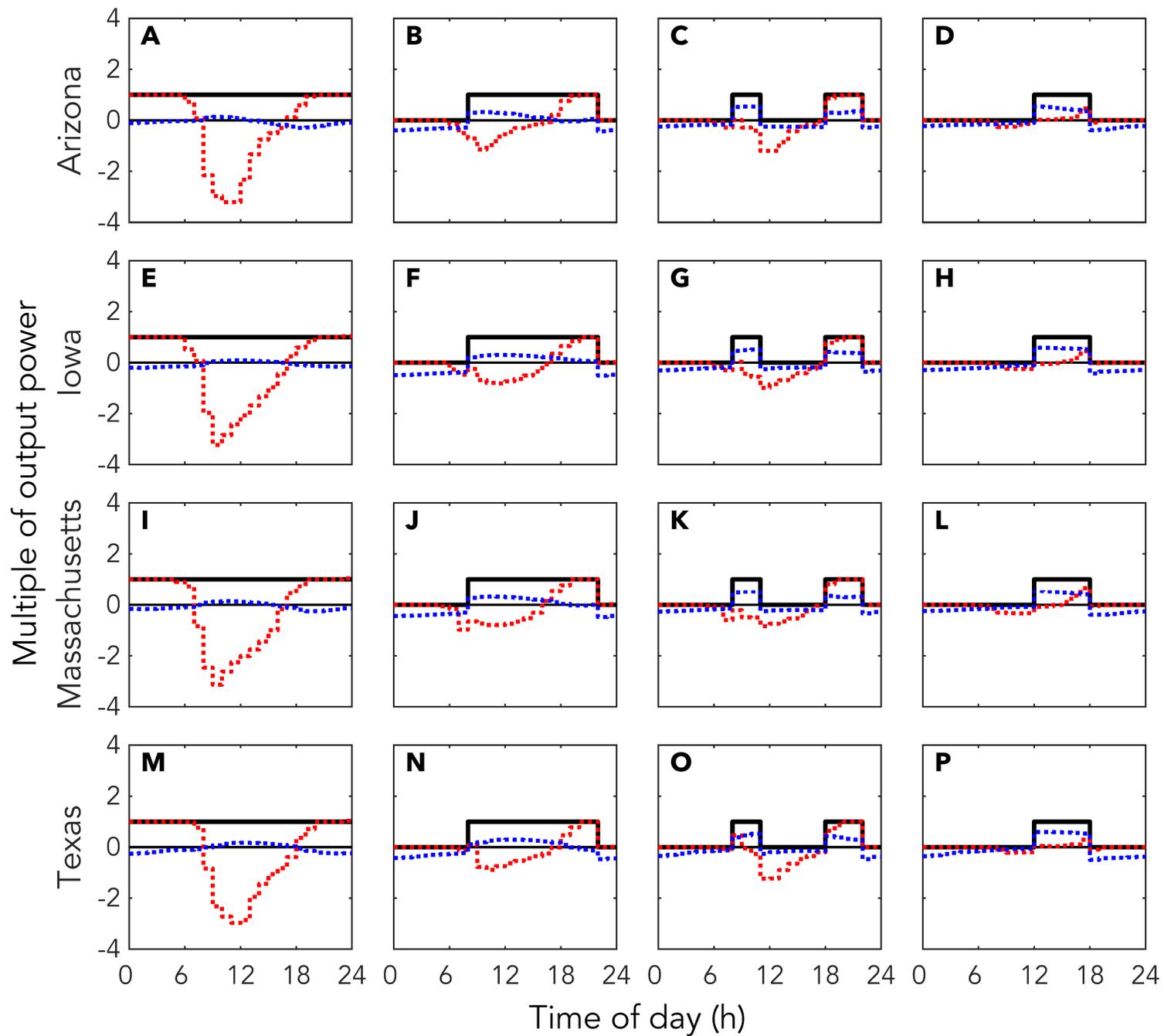
Evaluating stationary storage

- How much more improvement needed?

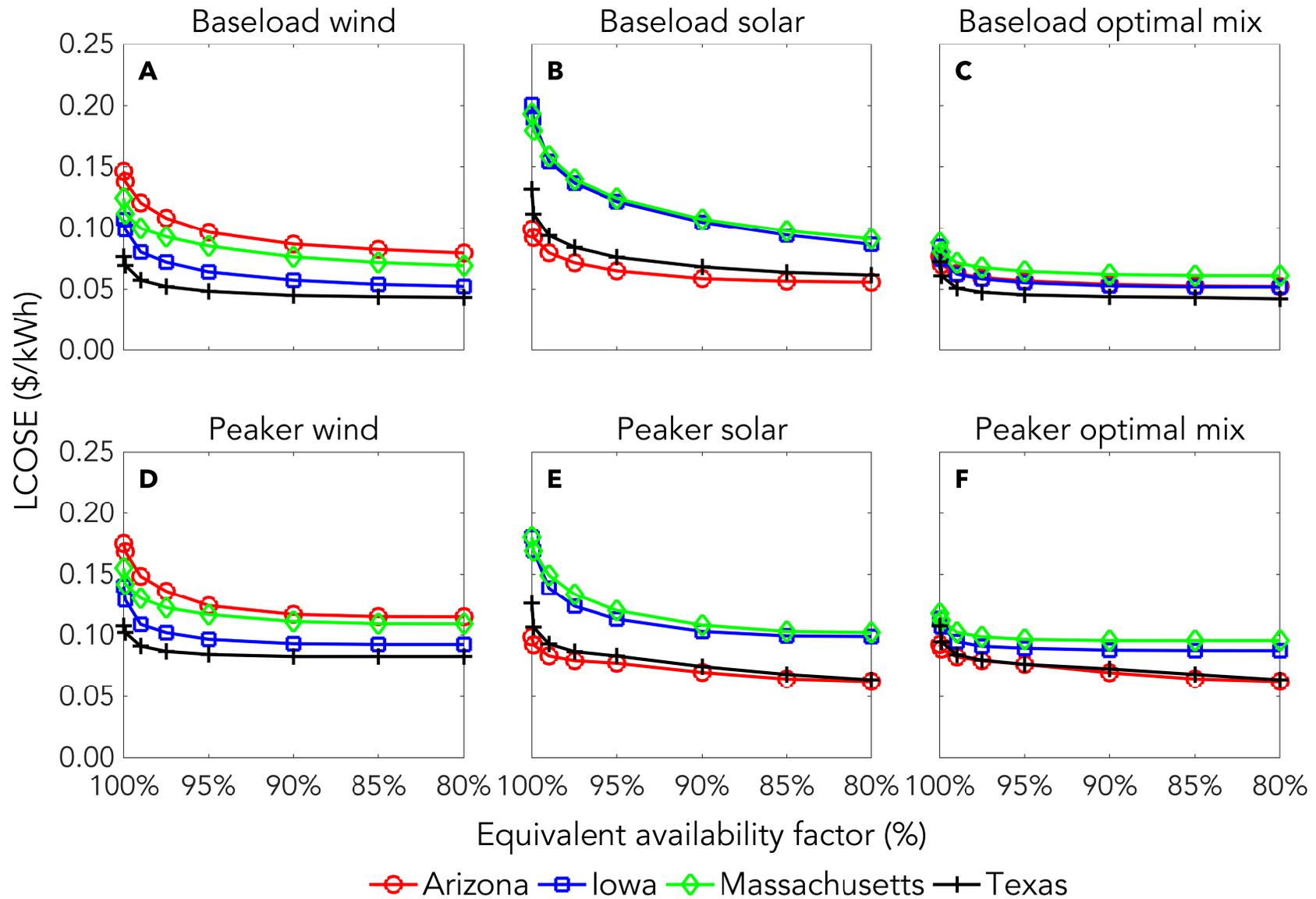
Consider fluctuations



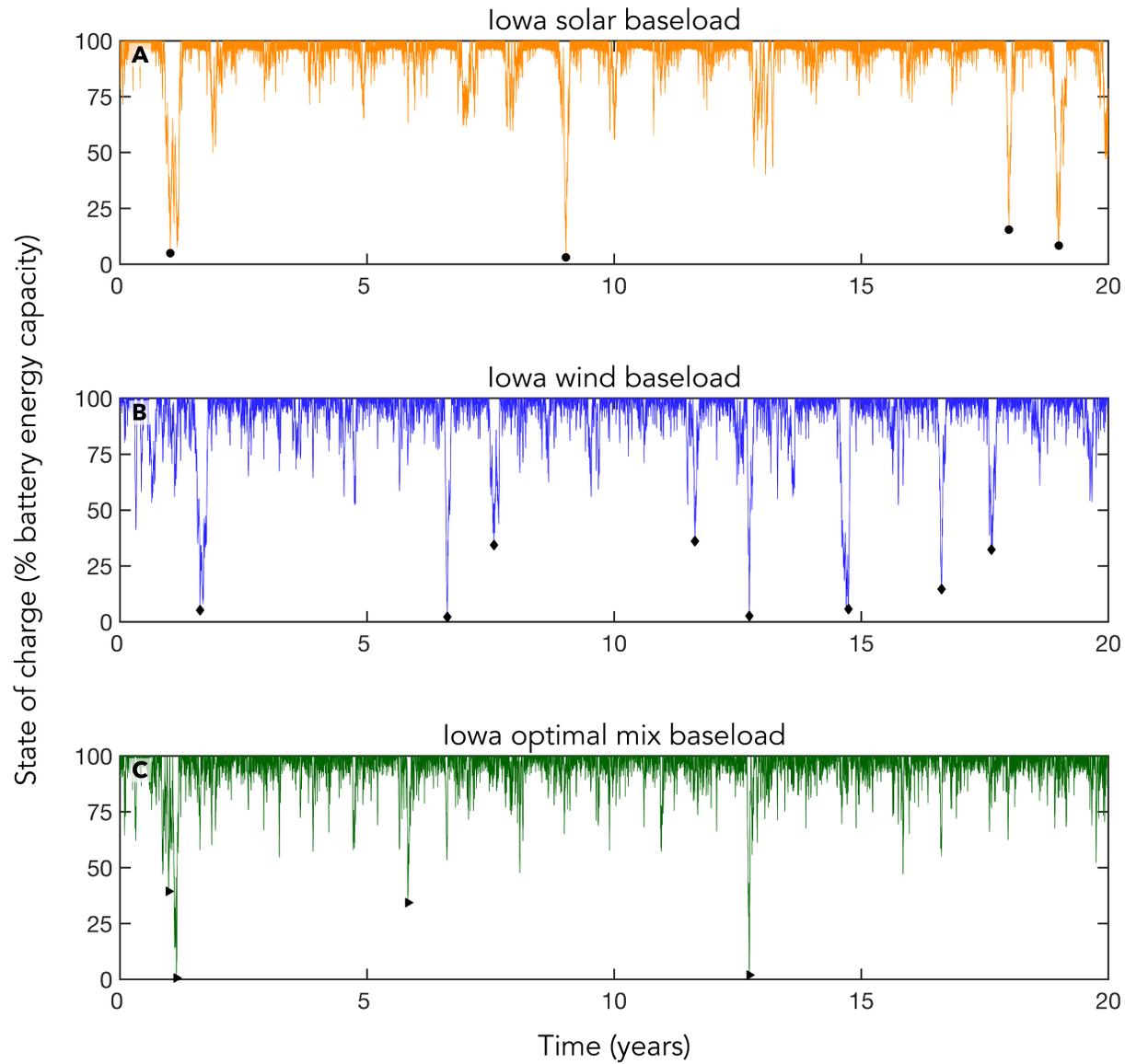
— Output shape ···· Storage operation for solar ····· Storage operation for wind



Results



Results



Evaluating stationary storage

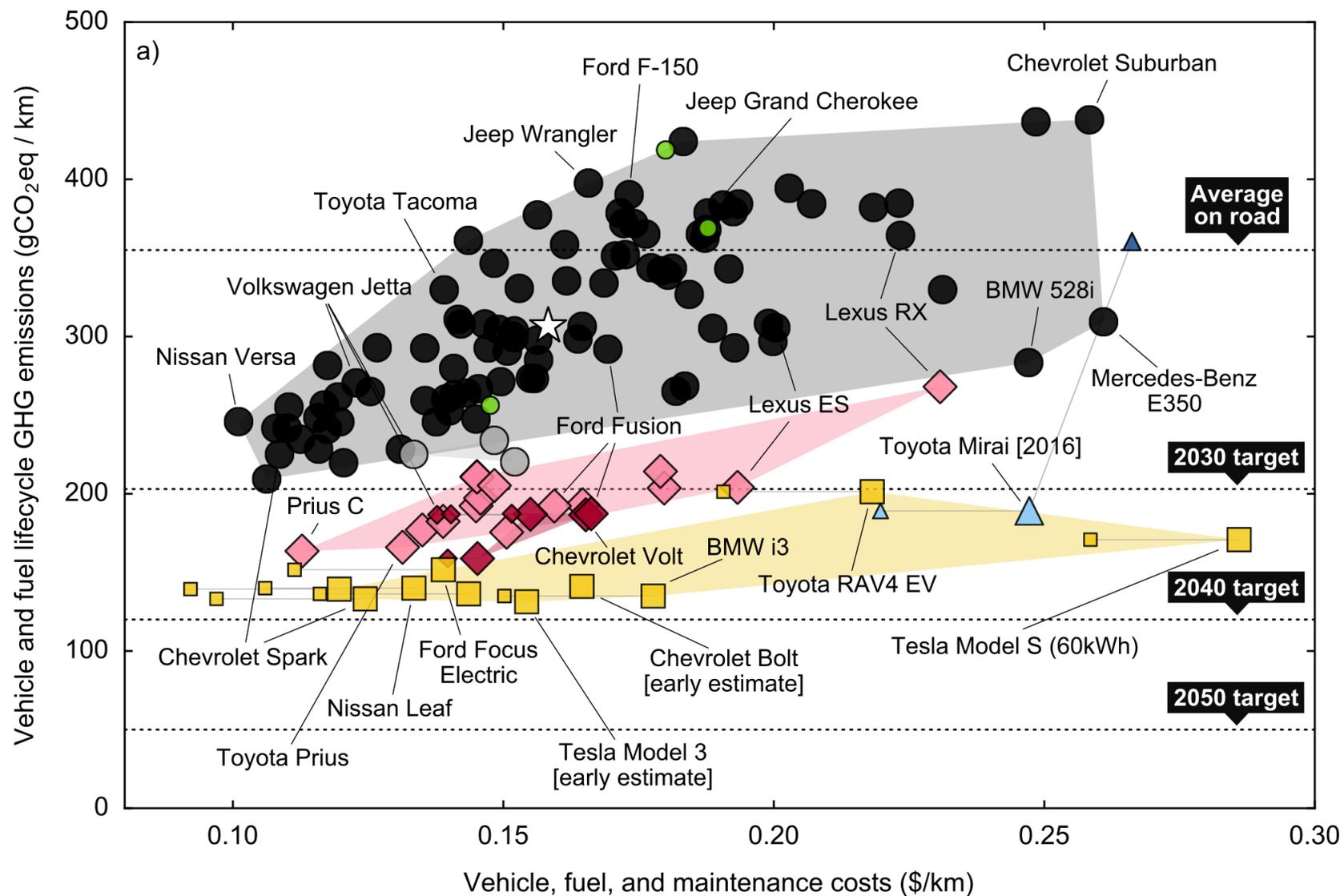
- System design and operation
 - ‘Oversized’ solar and wind energy (lots of excess generation)
 - Prediction problem is tractable (can achieve close to optimal operation)
 - Two paths: Ultra-cheap energy storage or energy storage *plus*
- How much more improvement needed?
 - Low energy storage capacity costs (\$20-150/kWh) and scalable materials
 - Energy storage *plus*: Batteries plus demand side management, transmission expansion, supplemental generation

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Cost and emissions of vehicle powertrains (see carboncounter.com)



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 - High energy trips and power system constraints define quantitative targets for battery energy density, fast charger locations, supplementary vehicles
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 - Automation and standardization can reduce soft costs

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