# Expert assessments on the future of direct current in buildings

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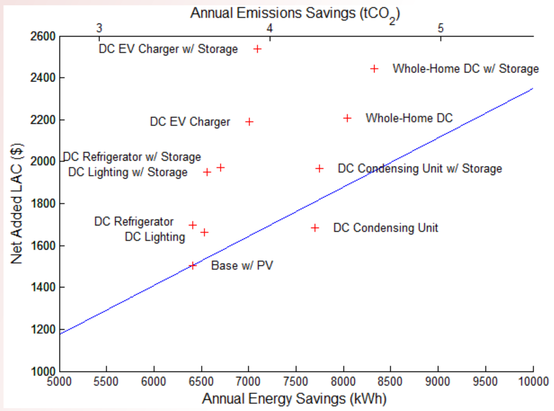
## Why DC?

- We now have semiconductor-based power electronics that function as efficient DC-DC transformers
- Consistent growth in distributed generation sources that generate DC
  - Solar PV
  - Wind
  - Fuel cells
- Growing fraction of DC use in buildings
  - CFL and LED lighting
  - All consumer electronics
  - Variable speed motors
- Unnecessary conversions between generation and end uses:
  - Decrease system reliability
  - Decrease distribution system efficiency
  - Increase capital cost

## Energy savings

- In previous research, we estimated the cost-effectiveness of direct-DC distribution of solar PV power in homes




## Nontechnical barriers to adoption

- Markets for DC appliances and components are small, resulting in high prices
- DC circuits at the residential level rely on wiring, circuit breakers, and switches which are not currently manufactured at a scale needed to supply broad adoption
- Engineers and technicians are not trained in DC systems, resulting in inflated design and installation costs of these systems
- Many utility programs are designed for AC (solar installation incentives, net metering programs)
- DC is still perceived by many to be more dangerous than AC

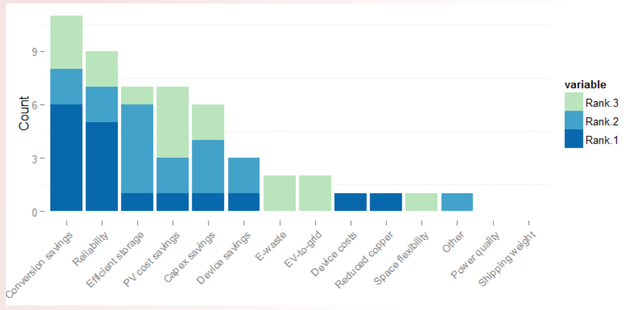
## Research Questions

1. Which characteristics of DC circuits most strongly promote and discourage their more widespread use in residential and commercial buildings?
2. What will be the voltage standards and current forms used in future DC buildings?
3. Will DC circuits be more or less expensive to install than equivalent AC circuits?
4. How do ongoing trends in electric end use technologies, electric motors, and power electronics affect the long-term viability of DC circuits in buildings?
5. How well-founded are the actual and perceived concerns of fire and electric shock safety and how might they affect adoption of DC circuits?
6. What are the biggest research needs to better understand this opportunity?

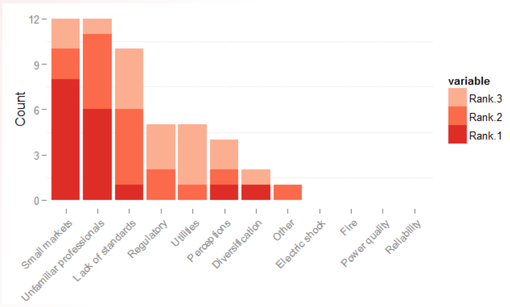
## Expert elicitation protocol

- Experts selected from:
  - Industry (6)
  - Research organizations (5)
  - Academia (1)
  - Implementation of DC systems (5)
- Elicitation protocol
  1. Introduction
  2. Ranking exercises
  3. Hypothetical building questions (cost, voltages)
  4. Open-ended discussion
- Responses recorded in Qualtrics, audio recordings of conversations transcribed

## Characteristics of direct current power distribution

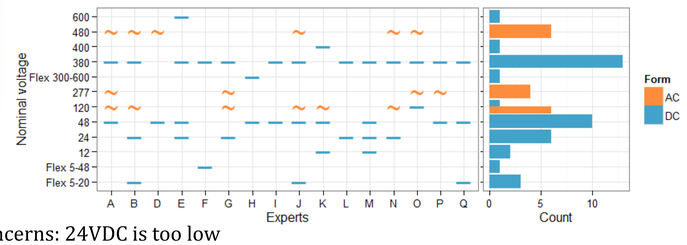



- Energy savings were the most highly cited positive characteristic
  - Many who ranked it highly said that energy savings alone will not drive adoption on a large scale
- Improved reliability, efficient storage integration, and PV cost savings were all ranked similarly and were often mentioned in relation to DC microgrids



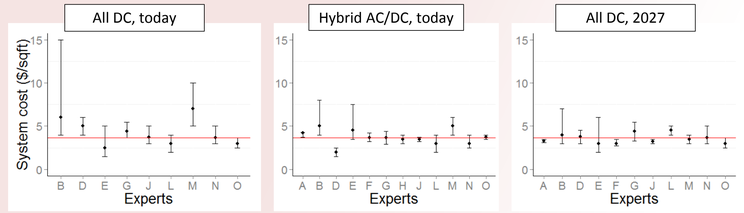

- Lack of developed markets for DC devices and components described as a “chicken and egg” problem
- Fire and electric shock safety were never mentioned as a major concern

## Voltage standards




- Concerns: 24VDC is too low
- Microgrids would benefit from bus voltages ≥ 760 VDC

## System costs




- Described a standard commercial office building, and asked to estimate the overnight capital cost to install DC distribution
  - Told to only consider the distribution system itself: panel boards, feeder lines, and installation
- Experts expressed very little confidence in their estimates, but show overall potential to reduce some costs
  - Low voltages allow for untrained installers

## Long-term viability

- Main focus so far has been on potential energy savings
  - Experts were not confident that these savings alone are enough to drive adoption
- Real focus should be on long-term trends which favor DC
  - Increasing attention to resilience
  - Increasing electronic loads
  - Increasing demand for centralized control of end uses
- Recommended actions
  - Continued research into applications and associated technologies
  - Identify niche cases where DC holds a clear advantage over AC and build pilot projects (military, cell towers)
  - Develop training programs for electricians and engineers

| Research objective | Mentions (Qty) |
|---|---|
| Understanding use cases where DC has a clear advantage over AC | 6 |
| Developing devices and components for DC systems | 5 |
| Integrating communication and power delivery | 4 |
| Building demonstration projects | 3 |
| Better understanding energy and cost savings potential | 3 |
| Better understanding power quality issues | 2 |
| Better understanding the potential for implementing DC as a retrofit | 1 |
| Better understanding transactive power potential of DC | 1 |
| Better understanding resilience benefits of DC | 1 |
| Training and educating professionals | 1 |
| Better understanding power scavenging | 1 |
| Developing voltage, metering, safety, and other standards | 1 |
| Better understanding electromagnetic emissions in DC buildings | 1 |

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