Emerging Pathways to Decarbonize the US Housing Stock

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Helsinki | September 11th 2021

What's The Issue?

HOMES USE A LOT OF ENERGY

- **New residential homes** are pretty good and are only about 1% of homes in any given year
- **Existing residential homes** use (almost) all the energy

WE NEED TO FIX EXISTING HOMES

- Why aren't all homes upgraded?
- What are the barriers to scaling upgrades?
- Can we make upgrade costs more manageable?

Switching from **Energy Efficiency** to **Low Carbon:**
We can't efficiency our way to zero carbon homes

How to Address Those Questions

STATE-OF-THE-ART REVIEW

- Recent documented developments for Energy Efficient / Low Carbon homes
- Past experiences and programs in the US and Europe
- What has been successful
- What has not been successful

MARKET SURVEY

- Understand what motivates and deters DER projects in today's market
- Identify promising approaches and technologies from the industry perspective
- Learn from people doing this work about barriers, what works, possible future strategies to get to scale

PROJECT COST SOLICITATION

- Learn from people currently doing this work about costs
- Breakdown costs by category (e.g. "sunshot" program for solar PV) to get "cost stacks"

State-of-the-art Review

REPORT

Emerging Pathways to Upgrade the US Housing Stock: A Review of the Home Energy Upgrade Literature (2021)

Brennan D Less, Iain S Walker, Núria Casquero-Modrego

Integrated Approaches at Large Scale

The Netherlands

Climate Mission The Netherlands

- "One Stop Shop" packaged approaches including: financing, planning, design, installation
- Makes it simple and easy for home owners.

www.climatemission.eu

EnergieSprong

- More than 5,000 homes.
- Simplified panelized retrofits pre-fab in factory.
- Best for simple homes.

https://energiesprong.org

Summary of 12 Deep Energy Upgrade Programs

Program Name	Number of Homes	Average Cost ($)	Average Site Energy Savings	Notes
Energy Upgrade California - CA	20,000	$6,300	274 kWh, 16 Therms	Actual bill savings. Predicted savings were typically much higher.
[illegible]	24	$5,[illegible]	39% delivered site energy savings; 64% fossil fuel and grid energy savings; 60% energy cost savings	Weather normalized savings from utility bills and fuel delivery invoices. Most projects electrified, including insulation, heat pumps and PV.
Zero Energy Now - VT				
Home MVP – MA: Deep	66	$49,126	48%	Predicted energy savings
Home MVP – MA: All	341	$21,675	33%	Half were electrified
Extreme Energy Makeovers - TN	3,420	$9,000	35% (4,900 kWh)	Deemed energy savings; affordable housing
National Grid Deep Energy Retrofit Pilot Community - MA and RI	60	$34.59 /ft^2	55%; 43% source energy savings	For 29 comprehensive projects
FSEC DERs - FL	10	$14,323	38%	DER increment was $7,074; affordable housing
FSEC DERs - FL	70	$16,424	30%	DER increment was $3,854; affordable housing
EnergyFIT Philly - PA	67	$14,257	36% gas, 22% electric	Affordable housing
EnergySmart Ohio - OH	11	$30,173		Cost data from Redwood Energy Guide
Home Upgrade by Home Energy Analytics - CA	400	Effectively zero	10%	CA's first pay-for-performance utility program; Includes automated energy end-use feedback and customized coaching
[illegible] by Home Energy Analytics - CA	[illegible]	Effectively zero	42% electric, 17% gas	Higher performing subset
Sealed - NY	338	$10,000	20% heating, 5% electricity	

IS THIS ENOUGH?

INDUSTRY NEEDS BIG CHANGES

Emerging Changes in DER

- **Shift away from high-cost super-insulation strategies**, with increasing recognition that traditional weatherization/home performance strategies are adequate for most dwellings.
- **Importance of when homes use energy**, and what type of energy they use and from what source.
- **Electrification as a core strategy**, with rapidly improving heat pump systems and lower-cost electrification strategies.
- **PV is becoming cheap and desirable**, necessitating a reassessment of energy upgrade priorities.
- **Financial payback arguments are challenging** due to low electricity and natural gas prices.
- **Sell comfort, convenience, aesthetics and health**. Big opportunity for PAYS program types with low upfront costs and pay for performance outcomes.
- **Emerging smart home technologies** are facilitating the ability to manage, reduce and communicate about energy use and carbon.

Getting to Scale

KEY BARRIERS TO SCALING UP DEEP ENERGY RETROFITS

- Projects focused solely on energy savings are not appealing to enough people.
- Market interest and acceptance is low amongst homeowners.
- Costs are too high.
- Economic justifications are challenging and possibly inadequate. **Low electricity** and **natural gas prices** make financial payback arguments challenging.
- Lack of trained workforce with the necessary skills.
- Lack of real estate market valuation of DERs/home upgrades.
- Energy programs need to add financing (PAYS / PACE).

Emerging Program Changes

Make DERs Appeal to Home Owners

Energy Programs – NEED TO

- Provide information.
- Use the right language
- Efficiency plus health
- Guaranteed energy savings
- One stop shop - approach
- Include rebates, attractive financing and other incentives (e.g. PAYS and PACE)
- Make it easy, make it fast.
- Invest in a well-qualified workforce that homeowners trust and use contractors as program ambassadors.

Emerging Program Changes

NEW METRICS

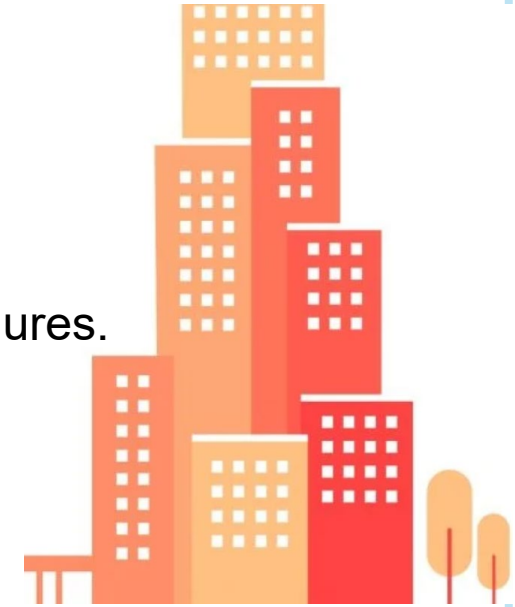
- CO_2 (and other Green House Gas) emissions.
- Grid interactivity and grid services.
- Peak demand and time of use.
- Electrical and thermal storage.
- Resilience
- Assessments of health, safety and IAQ associated with home energy upgrades including fire risk, CO, particles, wildfire and pandemic resistance

Emerging Technologies

Develop a standardized set of strategies that apply to the many building typologies that have broad consumer appeal

The strategies should focus on:

- Decarbonization and electrification.
- Demand-responsive and resilience-focused technologies including electric batteries and thermal storage.
- Heat pump technologies.
- Grid connectivity.
- Smart technology and web-connectivity.
- Resilience to natural and manmade disasters: wildfires, infrastructure failures.
- Health and safety.



Emerging Technologies

INCREASED INTEREST IN ELECTRIFICATION

- Electrification is a core strategy to achieving deep carbon reductions in buildings (and vehicles).
- Existing consumer demand for PV.
- Solar generation and storage is becoming more affordable.
- Improvements in Heat Pump Systems, particularly for cold climates and water heating.
- Reduced health and safety concerns.
- Elderly people safety concerns.

Market Survey

REPORT

DOE Deep Energy Retrofit Cost Survey (2020)

Wanyu R Chan, Brennan D Less, Iain S Walker

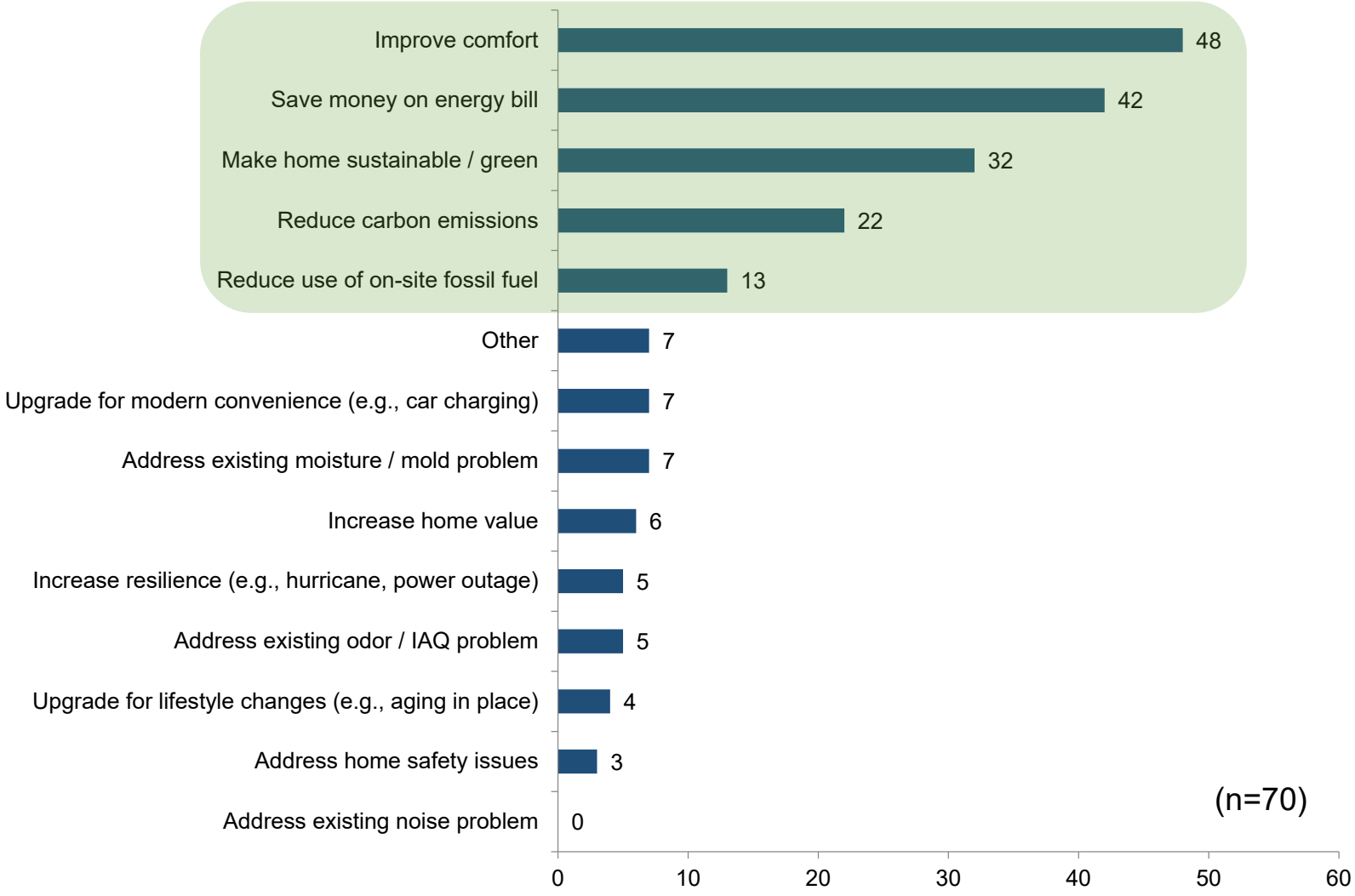
Market Survey

Survey questions organized by main sections of topic:

- Background information about past DER experiences of the respondent
- Consumer perspective on DER projects
- Home performance contractor perspective on DER challenges
- Promising technologies and approaches to advance DER
- Work scope and approaches to DER from past experiences
- Project costs for performing DER

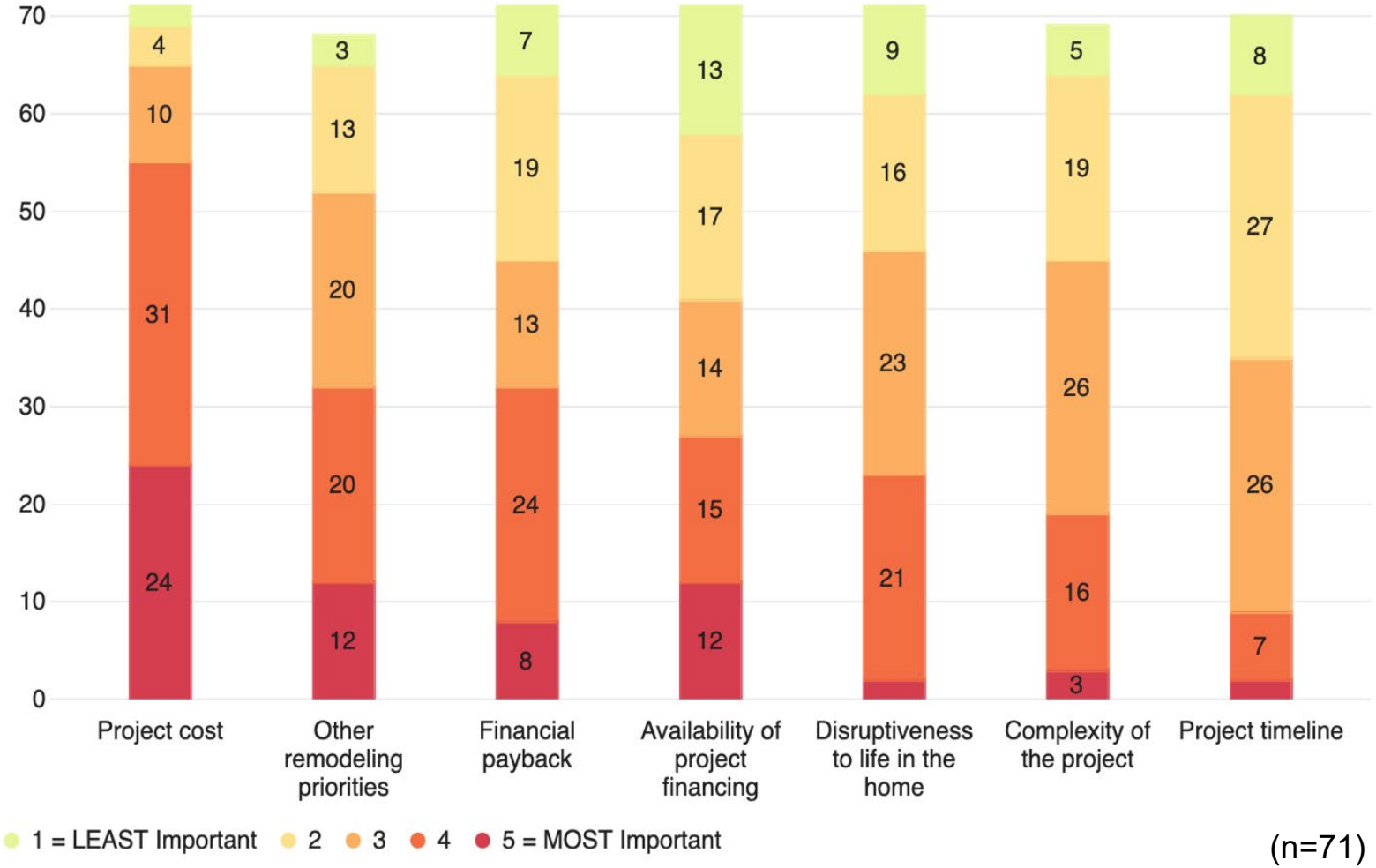
Customer Perspective

What are the main motivations of homeowners / building owners when seeking to perform a DER project?



Customer Perspective

Importance of factors when homeowners decide whether or not to proceed with a DER project



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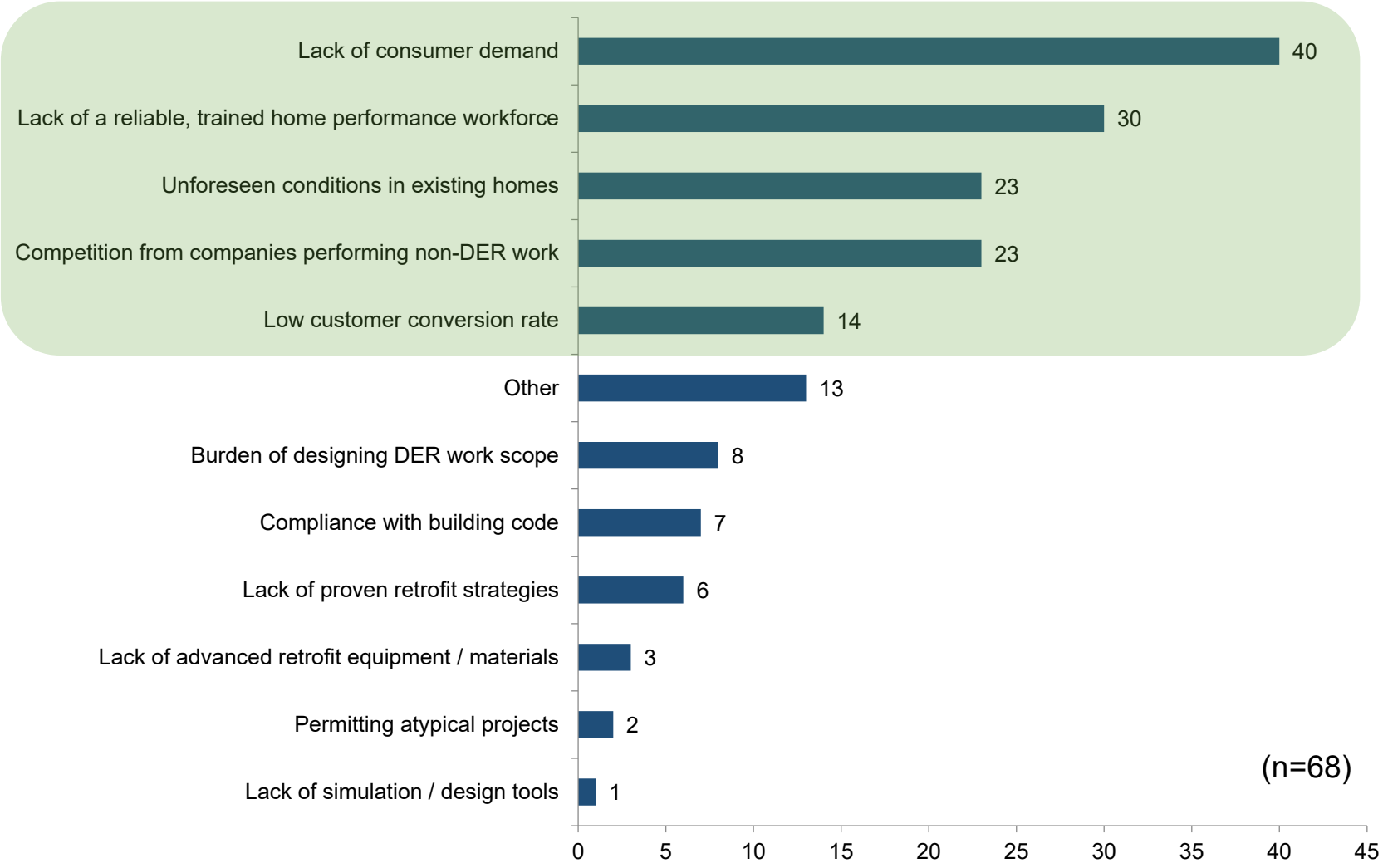
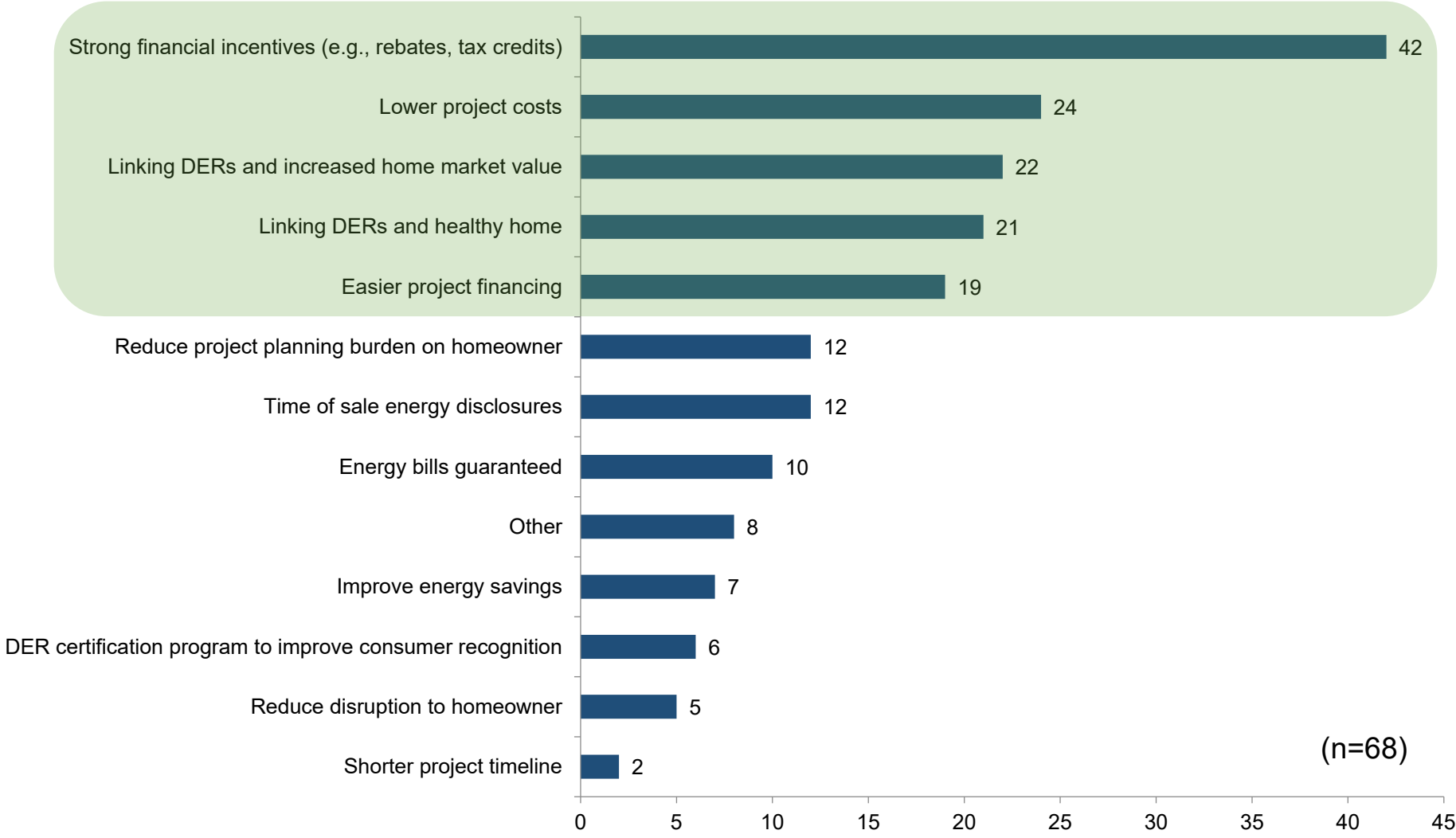
Industry Perspective

Aside from costs, what are the biggest barriers when performing DER projects?



Industry Perspective

What are the most effective ways to increase customer demand for DER projects?



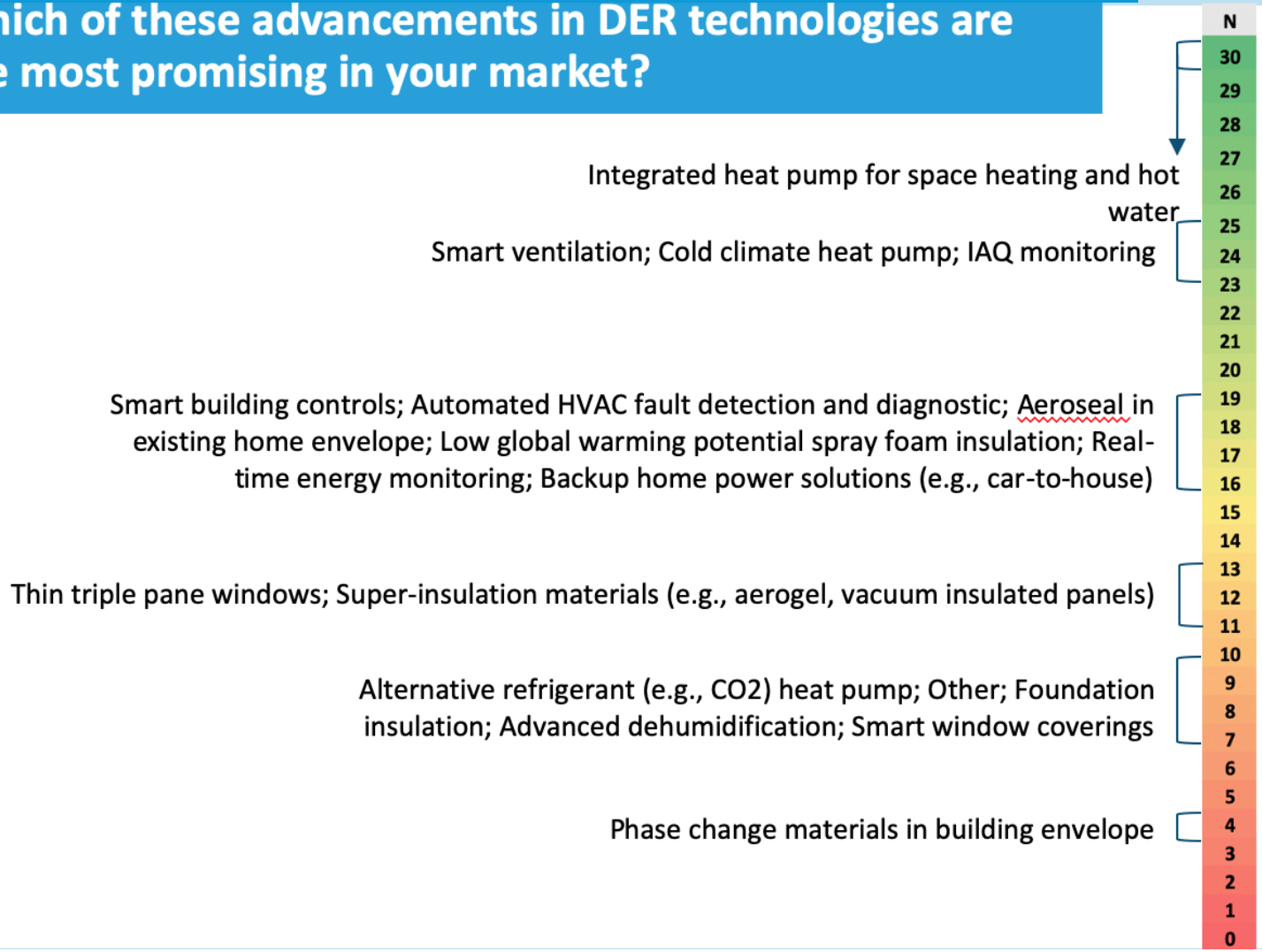
Advanced Technologies and Approaches

Rating of approaches for performing DER in your market.

Ratings =	1	2	3	4	5	Total Responses
"One-stop shop" with energy audit, work scope, financing, permits, construction, testing	2	2	10	21	28	63
Energy plus healthy home retrofit	1	5	23	22	13	64
Standard weatherization combined with heat pump and PV	4	13	18	19	12	66
Over-time DER aligned with equipment replacement / upgrade	6	7	20	16	15	64
Home electrification retrofit	10	8	18	18	10	64
Exterior retrofit with minimal disturbance inside home	9	20	14	14	5	62
Pre-fabricated panelized envelope retrofits (e.g., EnergieSprong)	16	23	11	9	4	63

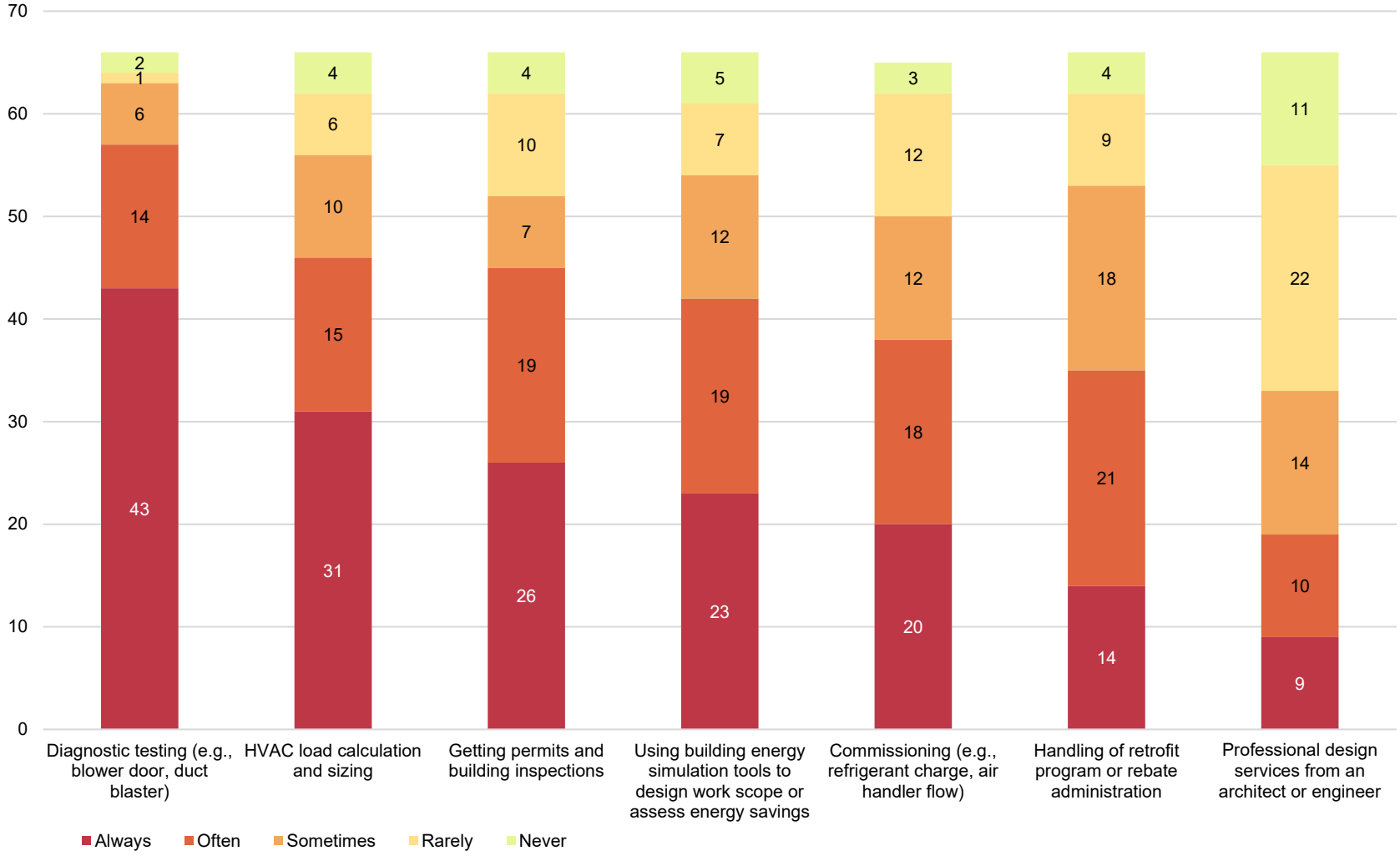
Advanced Technologies and Approaches

Which of these advancements in DER technologies are the most promising in your market?



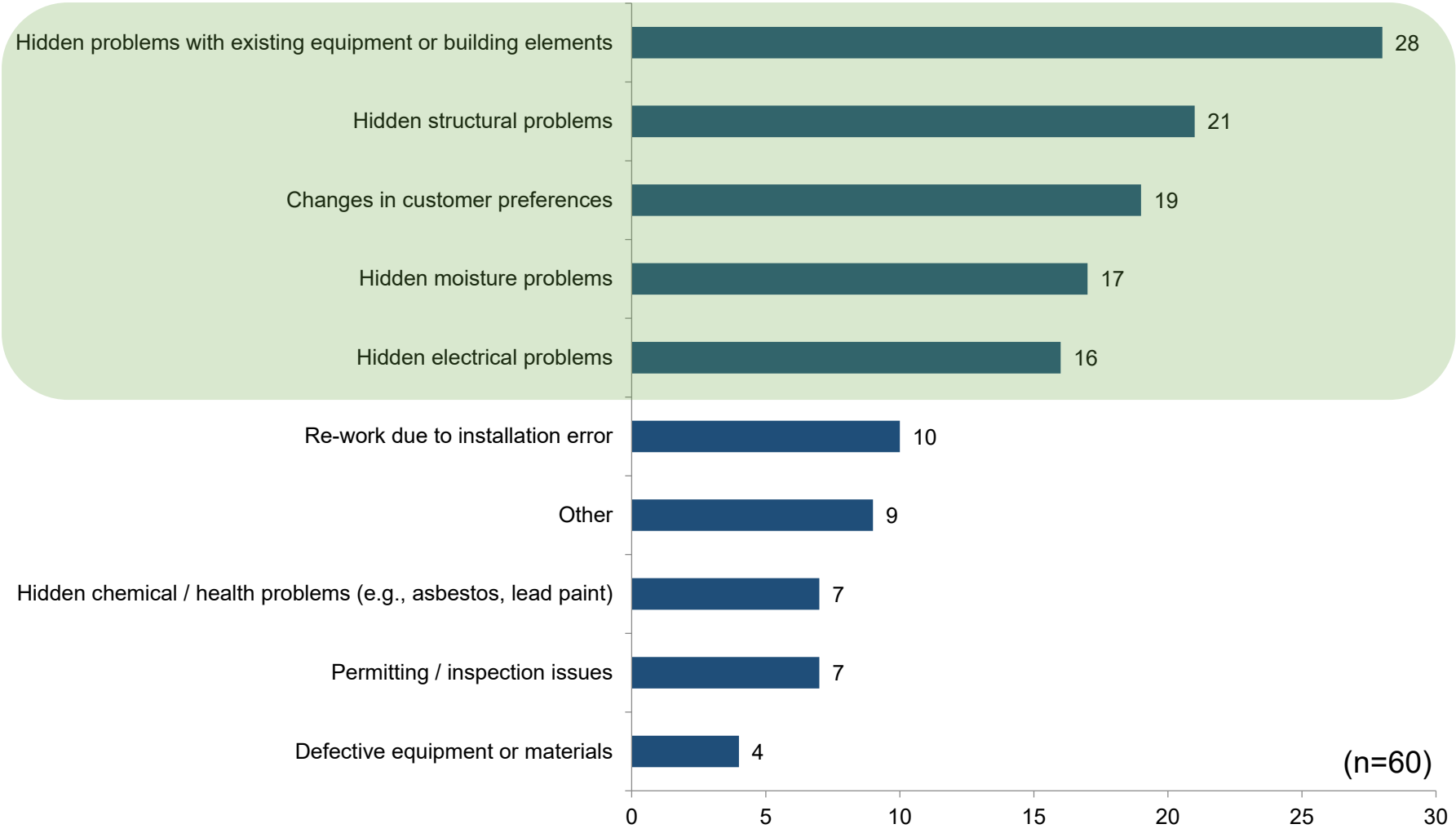
Work Scope and Approaches

Frequency of work elements that are included or involved in DER projects



Project Cost Estimates

Common causes of DER project cost increase.



Market Survey: Additional Suggestions from Contributors

DEEP ENERGY RETROFITS NEED TO

- Define its role in the **Energy Efficiency** market.
- Focus on **carbon reduction** over the life cycle of the home.
- Continue **technology innovations**.
- **Enable** contractors to make money and build partnership.
- **Include** disadvantaged communities.
- Rethink how to **drive** customer demands.
- **Broaden work scope** to include plug loads, inefficient plumbing.

Market Survey

- Homeowners motivations
  - Improve comfort and save money on energy bill.
  - Reduction of projects costs.
- Industry
  - Lack of consumer demand.
  - Lack of trained home performance workforce.
  - Strong financial incentives.
- Advanced Technologies
  - “One-Stop Shop”
  - Integrated Heat Pump for space heating and hot water.
- Existing Buildings
  - Hidden problems.

Thank You…!

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