e⁻Lab Summit

meeting recap

eLab® Electricity Innovation Lab AN INITIATIVE OF ROCKY MOUNTAIN INSTITUTE

thank you!

Thank you for being a part of e-Lab Summit 2017! Without your participation and perspectives, the collective work advanced at Summit would not have been possible. As you return to your work, we hope that the insights and connections that you made in New Mexico support you in meaningful and actionable ways. We wish you luck in all of your endeavors, and hope to see you at a future e-Lab event!

The e-Lab team

ground rules

you can say **who was there**
and **what was said**
but **not who said what***

Please remember these rules as you share the outputs of your work at Summit, including the contents of this document.

**without their permission*

follow-up

Offers of support from the e-Lab team

Don't hesitate to contact us with follow-up questions, comments, or requests related to e-Lab. For instance, we're happy to:

- make introductions to other Summit participants, e-Lab network members, or RMI staff
- share information on the collaboration frameworks we use (e.g., types of complexity, 4 ways of talking and listening)
- work with you to refine the Summit for 2018
- send copies of RMI reports or other analyses, briefs, etc.
- explore ways for you or your organization to get more involved with e-Lab, including as a full member

Please contact Mark Silberg (msilberg@rmi.org) with any follow-ups.

e-Lab Accelerator

May 1-4, 2018

Sundance Mountain Resort, Utah

What is e-Lab Accelerator?

e-Lab Accelerator is an invitation-only, four-day working meeting to accelerate high-impact and innovative projects at the electricity system's distribution edge.

Why attend e-Lab Accelerator?

We'll help you unlock opportunities to drive projects forward more effectively, and collaboratively. Specifically, Accelerator will give teams:

- **A structured working session** to make progress on their project or initiative
- **A rich learning experience** featuring experts on the latest thinking on new utility business models and distributed resources in the U.S. electricity sector
- **Tools and training** to conceptualize problems in collaborative and innovative ways
- **New alliances** to form a broader support network with other teams working on similar projects
- **A unique environment** conducive to creativity and breakthrough ideas

Is e-Lab Accelerator for you?

Accelerator teams comprise 5–8 people representing multiple project stakeholders. Successful teams bring together the right combination of vision, experience, knowledge, and commitment to a project that can accelerate change in the electricity system. Projects must be actively under development at varying levels of maturity.

pod topics

Smart Heating Electrification

Infrastructure Planning and New Mobility

Blockchain and Transactive Energy

Rate Design Pathways

Value Stacking for DERs

Distributed Grid Infrastructure

Utility Business Model Pathways

LMI-Focused Utility Business

your pod's recap is in the next section

Thermal electrification

Pod summary


Smart Heating
Electrification

smart heating electrification

e- Lab Summit

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Summary

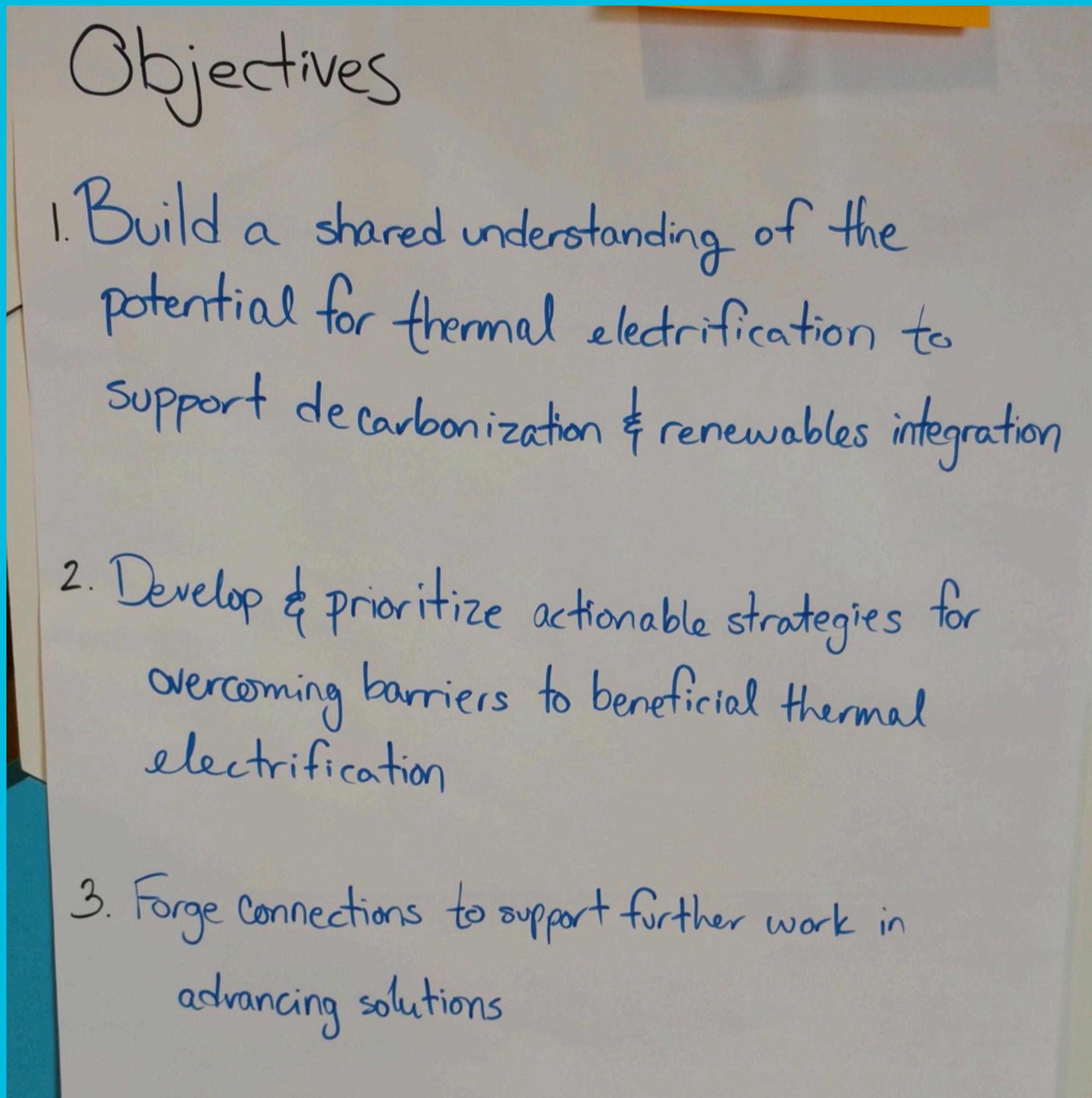
Thank you all for attending eLab Summit 2017! The thermal electrification pod had great energy and coalesced around great strategies to advance beneficial electrification. Here are a few concluding thoughts about what we accomplished:

- We rallied around the vision that thermal electrification is critical to meeting environmental goals, most specifically to achieve the aggressive economy-wide decarbonization targets needed to avoid the worst consequences of climate change
- We agreed that electrification can create new flexible devices that support grid operations in a highly renewable future, but this will take a concerted effort to bundle demand flexibility with new offerings
- We identified prominent barriers in suitability of existing buildings and awareness among contractors and consumers, and developed approaches to overcome these barriers
- We determined that we are at the early stages of a market transformation, and spurring the first phase of early adoption can focus on supporting widespread electrification of new buildings, influencing utility and regulatory decisions on gas distribution infrastructure by highlighting the opportunity for “non-pipes alternatives”, campaigning to raise awareness, and supporting new financing mechanisms and common national specifications

Thanks for your enthusiasm and attention to this meeting this critical challenge! I look forward to working with you all to make this a reality.

- Mike

Our objectives

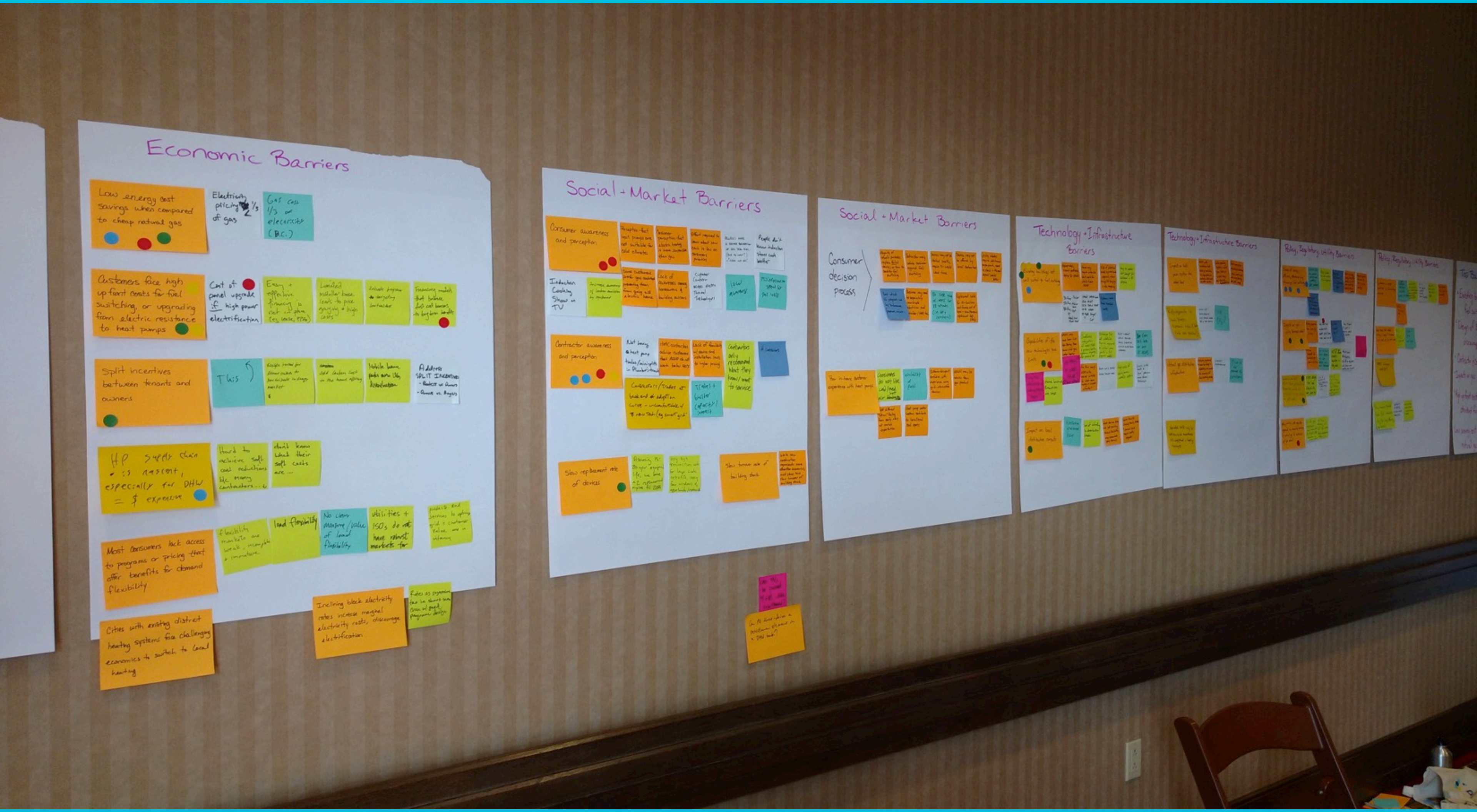


Future vision for thermal electrification:

Electrification of residential and commercial building heating load is critical to meeting environmental goals, will create new grid assets, and is a feasible and cost-effective strategy

Mapping the barriers

Detailed barrier map



Priority barriers (by votes)

- Contractor and consumer awareness and perception (6)
- Existing buildings not well suited to fuel switching (6)
- Design of energy efficiency standards may discourage fuel switching (6)
- Customers face high up front costs for fuel switching, or for upgrading from electric resistance to heat pump options (5)
- Impacts on gas utility business model (4)
- Low energy cost savings when compared to cheap natural gas causes long payback times (3)
- Wholesale markets lack products or transaction pathways for controllable thermal devices to participate (2)
- Capabilities of the technologies have limits (2)

The following slides detail all the specific barriers mapped during Summit

Barriers: Policy, Regulatory, Utility (1 of 2)

Design of energy efficiency standards may discourage fuel switching

- Separate goals or mandates for kWh savings and Btu savings
- Focus on energy savings rather than emissions reduction, or other metrics to account for demand flexibility benefits
- Utilities with low growth forecast have weakening DSM mandates
- Policy to focus on grid connected WH as a requirement
- Antiquated, insufficient cost effectiveness tests
- Non-aligned utility EE policies (i.e., Xcel Wind promo yet incentivizing CFLs, with night-time generation)

Impacts on gas utility business model

- Strong opposition from pure gas utilities
- Uncertain tradeoffs for combined gas & electric utilities
- We must ask whether NG death spiral looks like coal or not
- Gas utility stranded assets
- Policy tail winds to invest in expanding natural gas infrastructure
- Gas utilities must evolve or die - develop zero-carbon feedstock
- Question: what to evolve to? Is this cost-effective? Will this scale?
- Set cost-effective all electric baselines in building code
- Must have all-electric tariff in regulated utilities = more baseline use or less cost

Wholesale markets lack products or transaction paths for controllable thermal devices to participate

- Rate designs for load flexibility, not just PV
- Lack of Time of Use pricing to incent new thermal equipment electrification and adoption

Barriers: Policy, Regulatory, Utility (2 of 2)

Many utilities, with regulatory approval, are promoting conversion to natural gas for customers not yet served

- Oil to gas conversions have accounted for significant GHG reductions in many states, but this strategy will not get us to deep decarbonization

Limitations or outright prohibitions on fuel switching promotion

- DSM incentive programs exclude fuel switching
- Lack of full cost accounting especially balance of distribution system installation comparing NG to electric ASHP
- Lack of policy direction for utilities regarding thermal electrification
- Lack of policy coordination between cities & states
- California three-pronged test
- PNW requirements for fuel neutrality

Most states lack carbon pricing, or apply it to power sector but not gas retail sales

- Example: RGGI in Northeast states
- Carbon price too low

Emissions-aware Demand Response?

Policy-makers provide fossil fuel subsidies (e.g., for high efficiency gas boilers)

Other

- Challenge to use codes and standards to drive thermal electrification
- Raise the federal minimum standard to support GHG emissions reduction

Barriers: Technology and Infrastructure (1 of 2)

Existing buildings not well suited to fuel switching

- Appropriately sized & ventilated space for HPWH
- Size of electrical panel in building (e.g., homes with 100A panel), especially as home EV charging is combined with thermal electrification
- Home may require extensive duct work for whole-home ASHP retrofit
- Hydronic whole home transition costly
- Easy to explain cost benefit for customers in DR program
- Need low power option (e.g., for trailer home - 30 Amp, modular home - 50 Amp, apartment - 80 Amp)
- Need 100A home solution (e.g., 15A ASHP, 15A HPWH, 15A stove, 15-30A dryer, ? Car)

Capabilities of the technologies have limits

- ASHP suitability for whole-home heating, without backup, in coldest climates
- *Note that the very newest technologies are capable of this for many homes, with supplemental duct heater; 80% of rated output down to -13 F
- HPWH may have lower First Hour Rating than same-sized gas water heater
- *Question: is this a code issue?
- Ineffective integration of mixed ASHP and existing heating systems - especially after period of use
- Technologies that add controllable thermal equipment to virtual power plants and DR programs needed
- Most current HPWH require costly electrical circuit and/or panel upgrades
- Costs still high for some cold climate ASHPs
- High costs of whole home retrofit options
- Actual COP < Rated, higher standby losses
- Not enough in-field results to “prove” performance across thermal technologies
- Electric baseboard thermostats are crap

Barriers: Technology and Infrastructure (2 of 2)

Impacts on local distribution circuits

- Some distribution circuits are heavily loaded, and increases in peak demand could require costly upgrades to distribution infrastructure
- Most installations are not controlled, not reacting to price signals and thus may exacerbate peak issues on local and bulk power systems
- Distribution transformer sizing
- Loss of redundancy in distribution circuits

Impacts on bulk power system from added load

- If new electric load is not controlled, it could exacerbate operational challenges to the bulk power system (e.g., morning & evening showers drive peaks that exacerbate the duck curve; or residential heating may exacerbate winter morning peaks on coldest days in winter-peaking systems)

Refrigerants in heat pumps present risk if leaks occur (high GHG potential)

- High GWP refrigerants, high leakage concerns, especially in space heating
- Use CO2 refrigerant?

Continued expansion of natural gas distribution infrastructure

- Extending gas service to more buildings is expensive, and once a building is connected to gas distribution, the economics of electrification become less attractive
- Stranded infrastructure
- Potential to use it for renewable NG (biogas / syngas)

Barriers: Social and Market (1 of 3)

Contractor awareness & perception (4)

- Some HVAC contractors continue to advise customers that ASHP technologies do not work below 40F
- Lack of familiarity with device and installation leads to higher pricing
- Not having heat pump tanks / minisplits in contractor's truck
- Trades + builder capacity / interest
- Number of contractors qualified / offering new equipment
- Contractors only recommend what they know / want to service
- Contractors / trades at back end of adoption curve - uncomfortable w/ new tech (e.g., smart grid)

Consumer awareness & perception (2)

- Lack of awareness among homeowners & building owners
- Perception that heat pumps are not suitable for cold climates
- Some customers express a preference for gas cooktops, preventing them from pursuing a fully electric home
- Consumer perception that electric heating is more expensive than gas (stemming from widespread electric resistance heating)
- Effort required to learn about a new technology is low among consumers' priorities
- Lack of awareness of thermal electrification technologies in policy making circles
- Customer confusion across electric thermal technologies
- Misinformation spread by gas utilities
- People have a better perception of gas than electric (due to cost) -- "clean natural gas"
- People don't know induction stoves cook better
- Suggestion: Induction cooking show on TV
- Need: increase awareness of carbon emission by equipment

Barriers: Social and Market (2 of 3)

Slow replacement rate of devices (1)

- Water heaters are replaced every 10-15 years, furnaces ~20-30 years
- Assuming 15-20 year equipment life, we have ~2 replacement cycles until 2050
- Very high transaction cost for large scale retrofits, very few windows of opportunity / replacement

Slow turnover rate of building stock

- While new construction represents a more attractive economic case, in most places the building stock is turning over very slowly

Consumer purchase experience

- Devices may not be offered by local contractors
- Devices may be available but not stocked locally, requiring 3+ weeks lead time
- Customer may need to separately coordinate plumber and electrician for HPWH install (or, similarly HVAC technician and electrician for ASHP)
- Contractors may advise customer against fuel switching
- Majority of retrofit purchases are made when equipment fails, replacement is needed ASAP, and customer has less time to consider benefits of fuel-switching
- Utility rebates may require additional paperwork, and come as a check several weeks after customer pays full price up front
- Replacement cycles for air conditioner and furnace may be out of sync, making simultaneous replacement with ASHP less practical
- Point of purchase rebate not available
- Best intent EE programs can be burdensome (paperwork, requirements)
- No single point of access for EE upgrades (e.g., heat pump + insulation)

Barriers: Social and Market (3 of 3)

In-home customer experience with heat pump devices

- HPWH contribution to localized cool spots in home
- HPWH may be noisier than gas product
- Customer with ASHP may not feel the same level of hot air from vents (compared to gas furnace), even when air temperature is achieving set point
- Customers may be confused by experience with flexible devices and demand response participation
- Limited availability of parts
- Consumer perceptions informed by legacy of experience with older, poor performing systems; including cold/med warm air blowing on them

Barriers: Economic (1 of 2)

Customers face high upfront costs for fuel switching, or for upgrading from electric resistance to heat pump options (5)

- Cost of panel upgrade if high power electrification
- Easy + effective financing is not in place (e.g., lease, PPAs)
- Limited installer base leads to price gouging and high costs
- Rebate program targeting contractors (need)
- Financing models that balance first cost barriers to long term benefits (need)
- GSHP offer attractive performance in colder climates but incur much higher installation costs

Low energy cost savings when compared to cheap natural gas causes long payback times (3)

- Gas cost ⅓ of electricity (e.g., British Columbia)

Split incentives between tenants and owners (1)

- Easier portal for homeowner to participate in energy market (need)
- Add carbon cost to the home efficiency (need)
- Mobil home parks own UG distribution

Barriers: Economic (2 of 2)

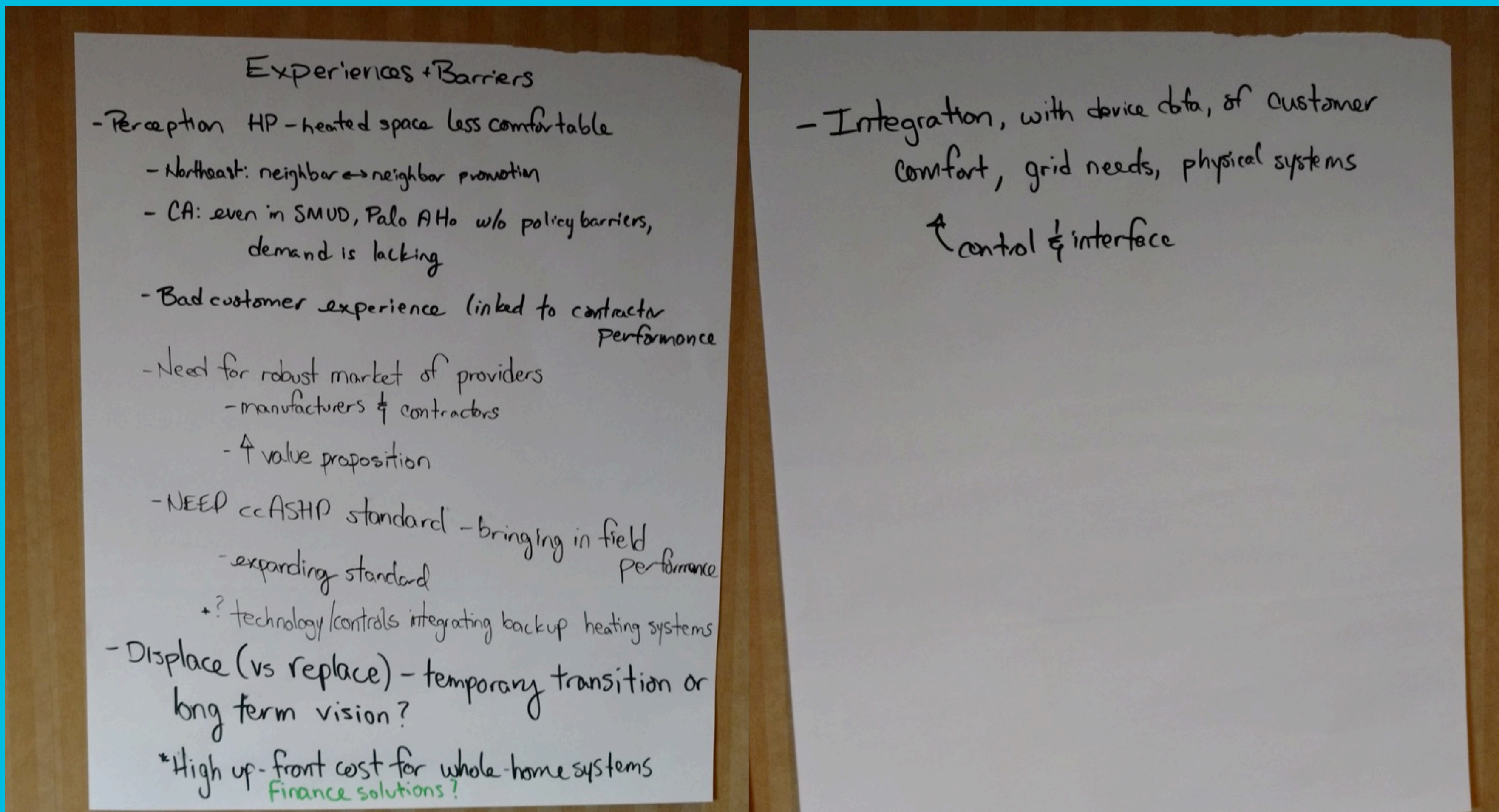
HP supply chain is nascent, especially for DHW, leads to high cost
- Hard to achieve soft cost reductions because many contractors don't know what their soft costs are

Most consumers lack access to programs or pricing structures that offer any benefit for the demand flexibility electric devices can provide
- Utilities and ISOs do not have robust markets for load flexibility
- No clear measure / value of load flexibility
- Flexibility markets are weak, incomplete & immature
- Products and services to optimize grid + customer value are in infancy

Inclining block electricity rates increase marginal electricity costs, discourage electrification
- Rates as regressive tax in short term even with good program design

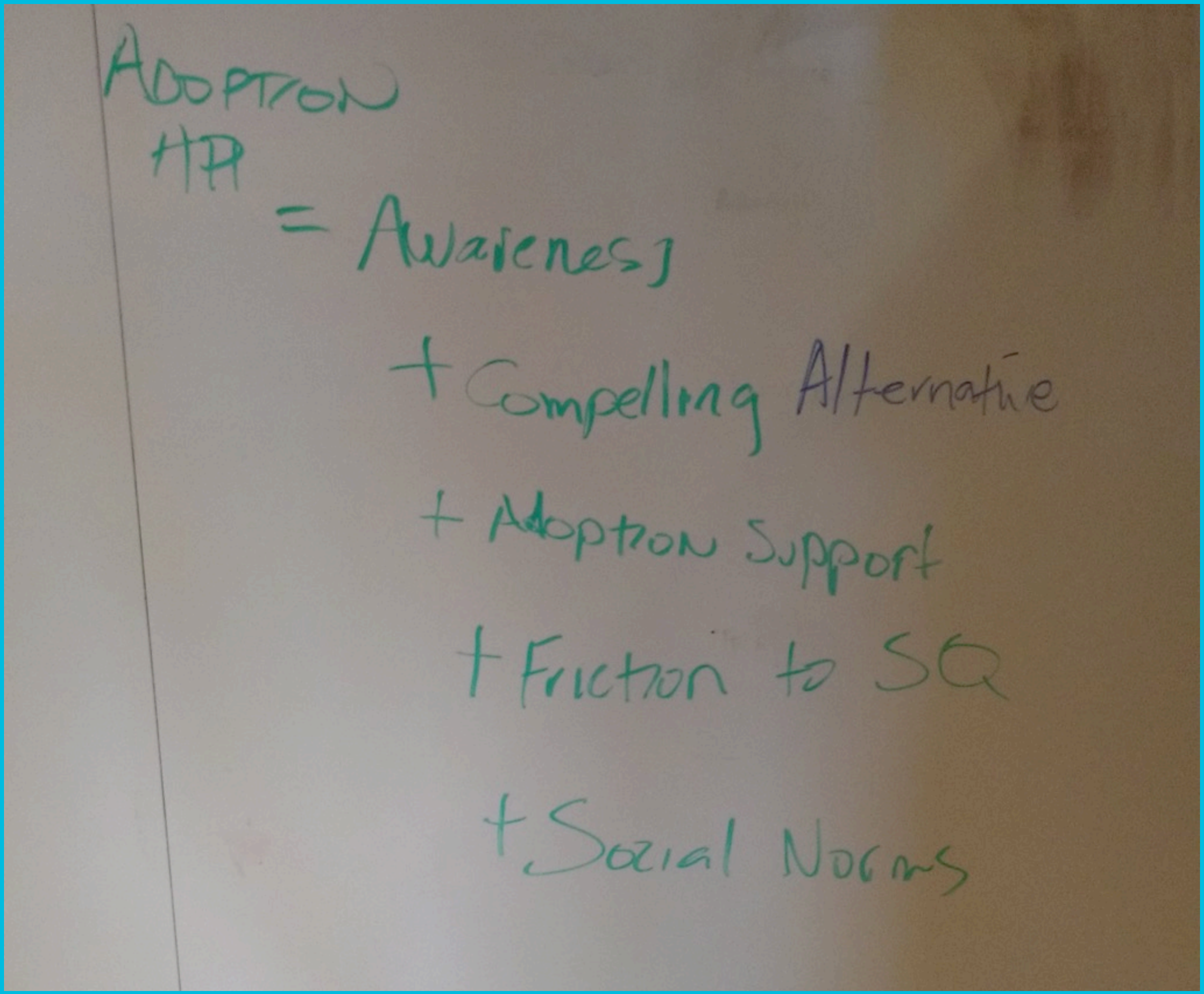
Cities with existing district heating systems face challenging economics to switch to local electric heating

Further discussion on experiences with barriers

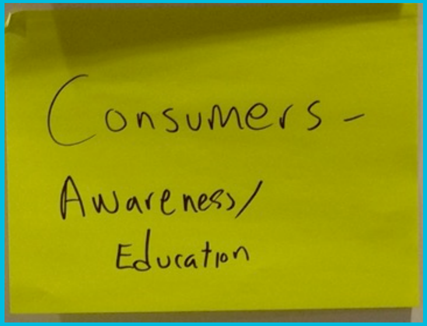


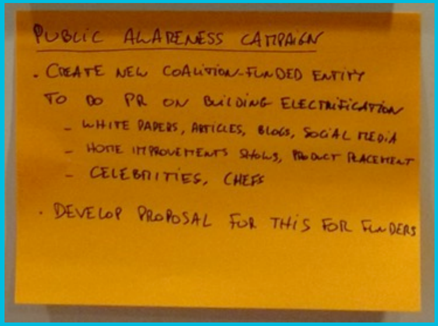
Leverage points to transform the system

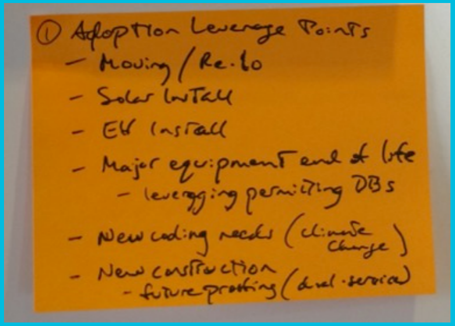
Framework for what's needed for heat pump adoption

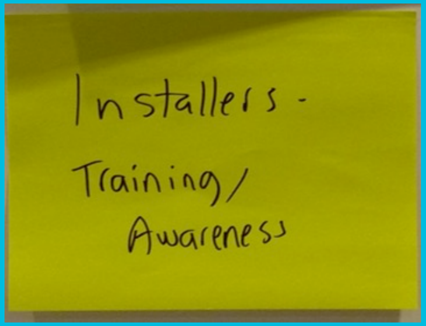


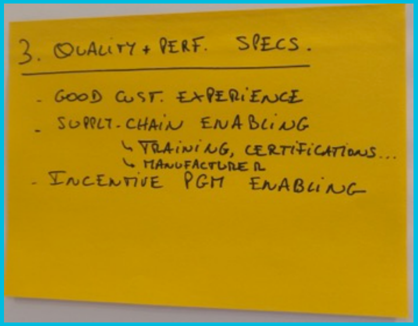
Leverage points to change the current system (1 of 2)

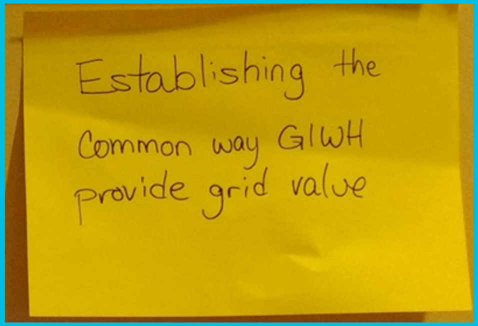


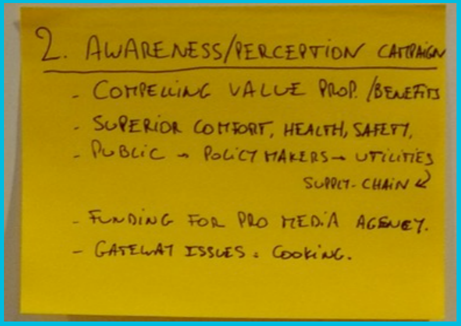


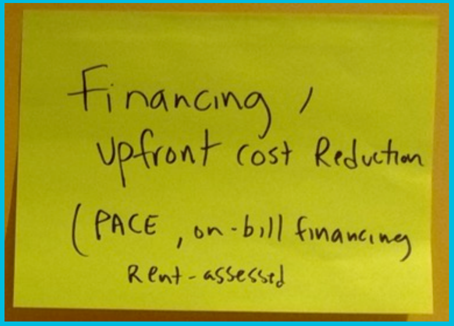




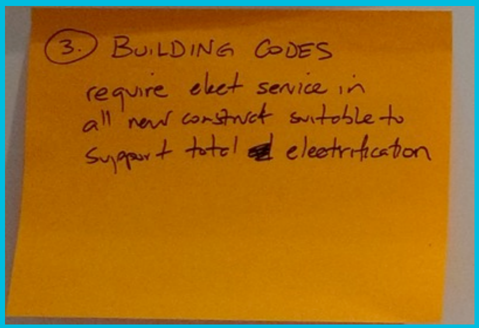


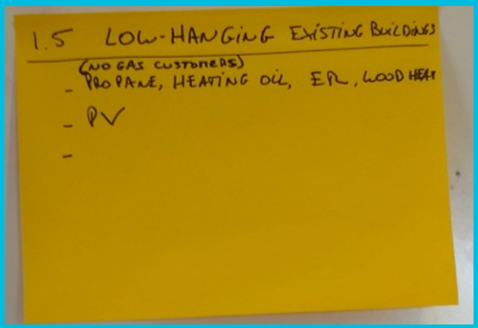


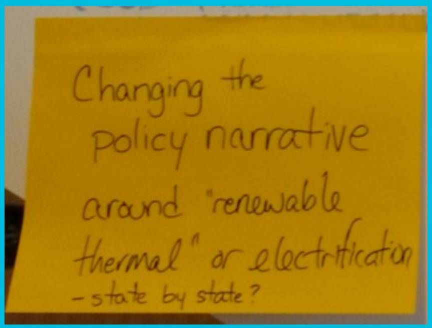


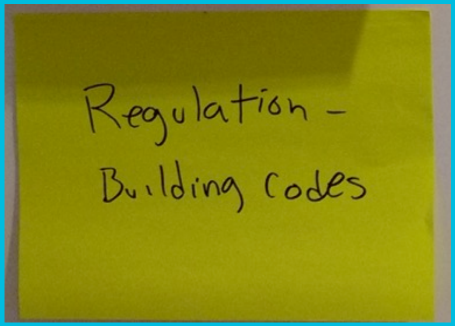


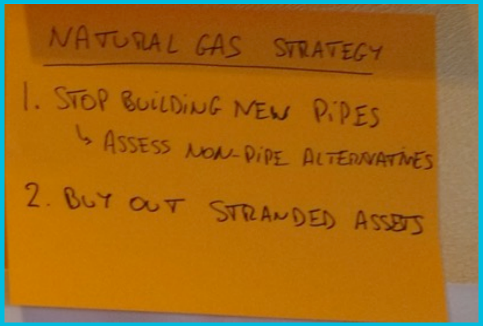
Leverage points to change the current system (2 of 2)

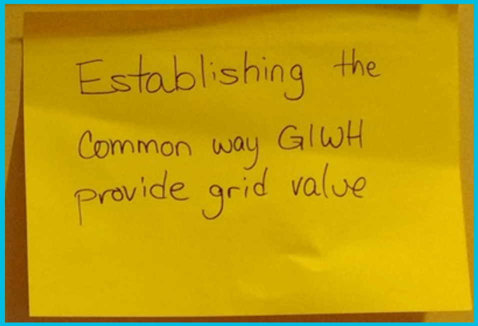


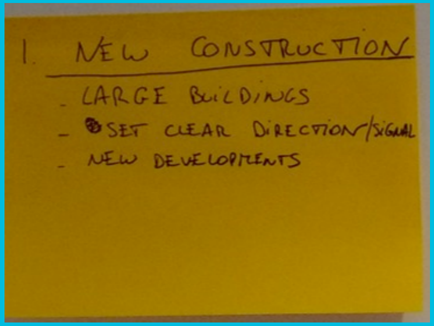


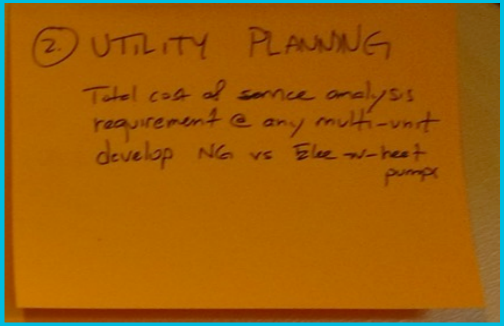








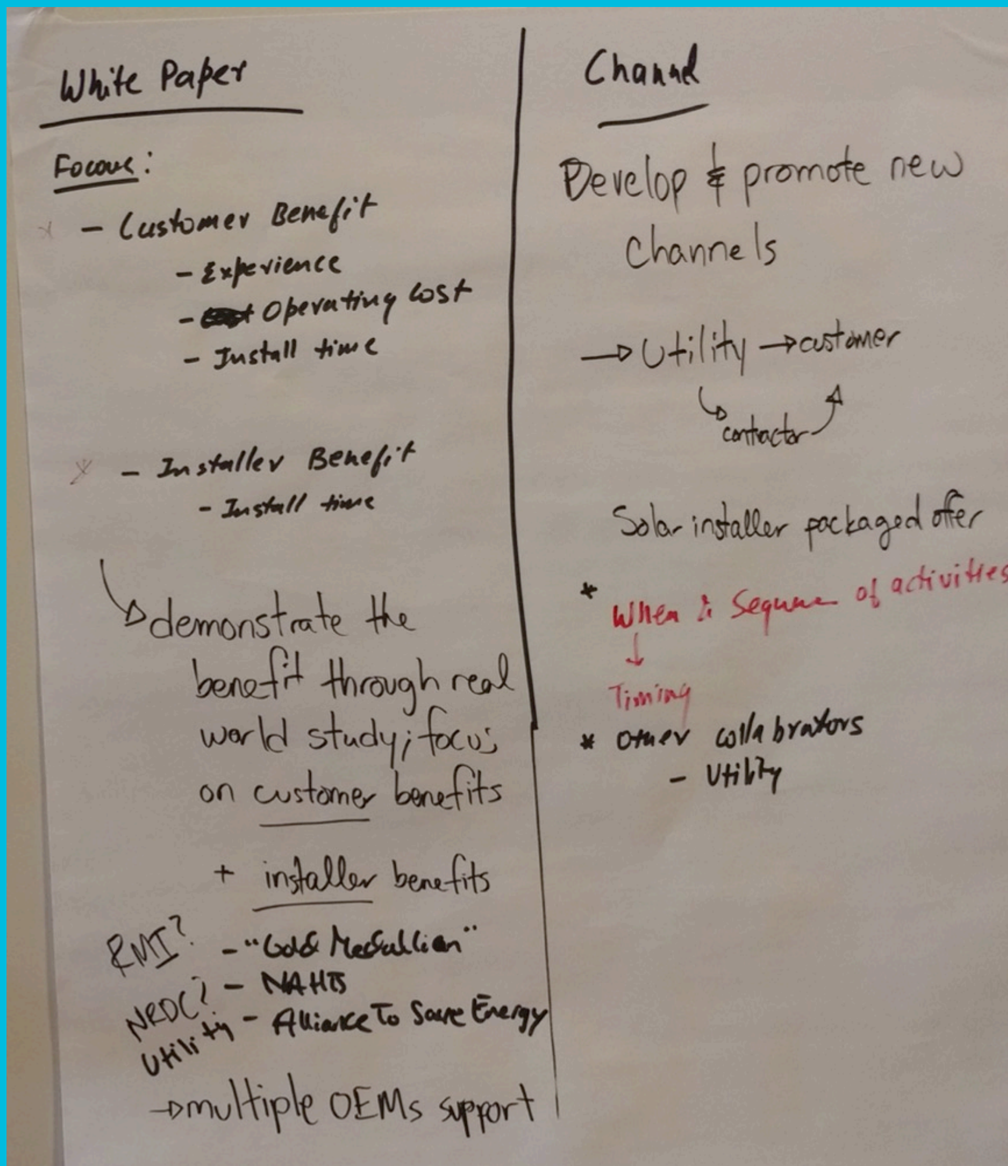




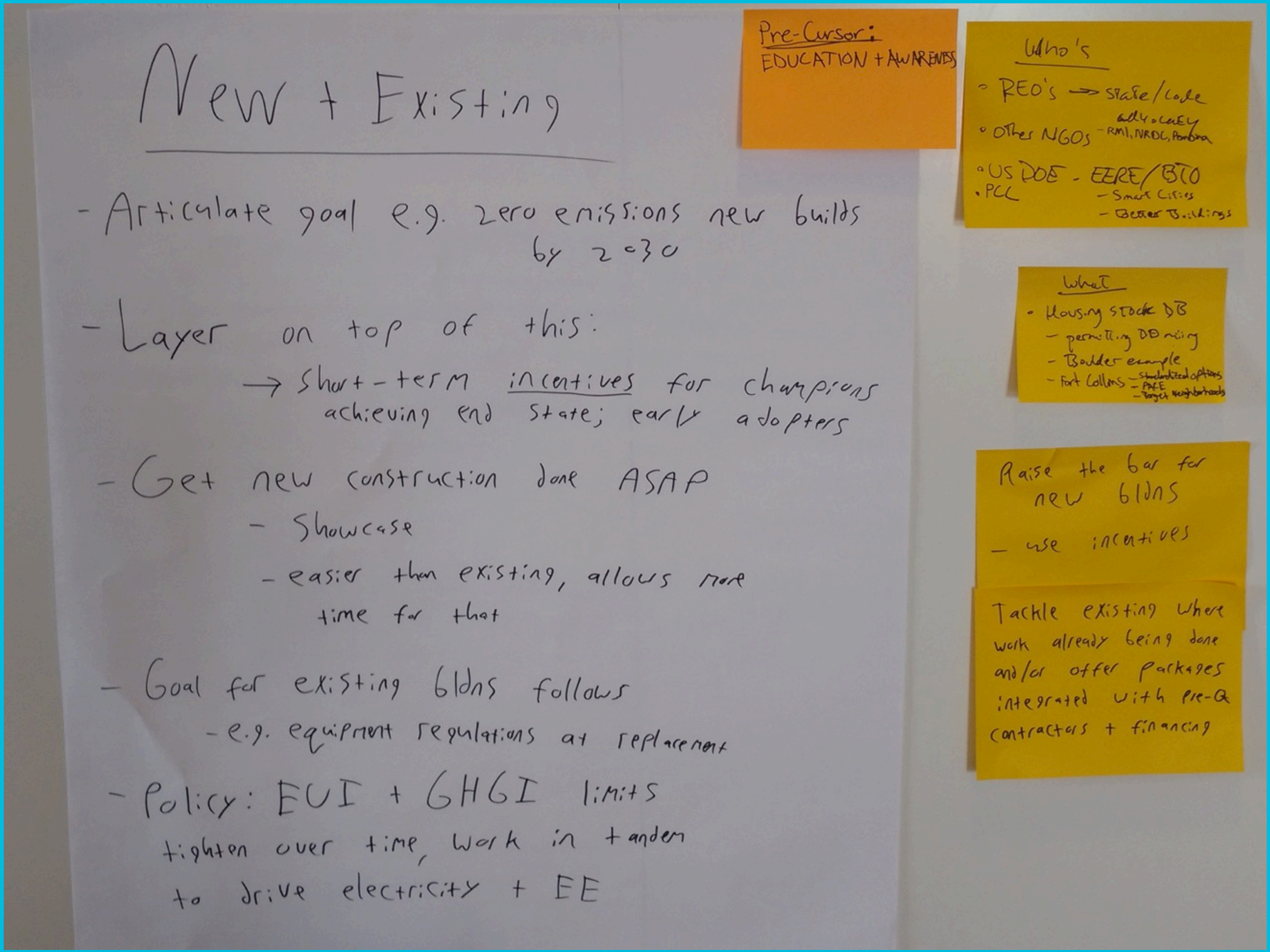
We prioritized 5 areas for innovation

1. Awareness building
2. Existing building issues
3. New construction
4. Common specifications / standards
5. Financing

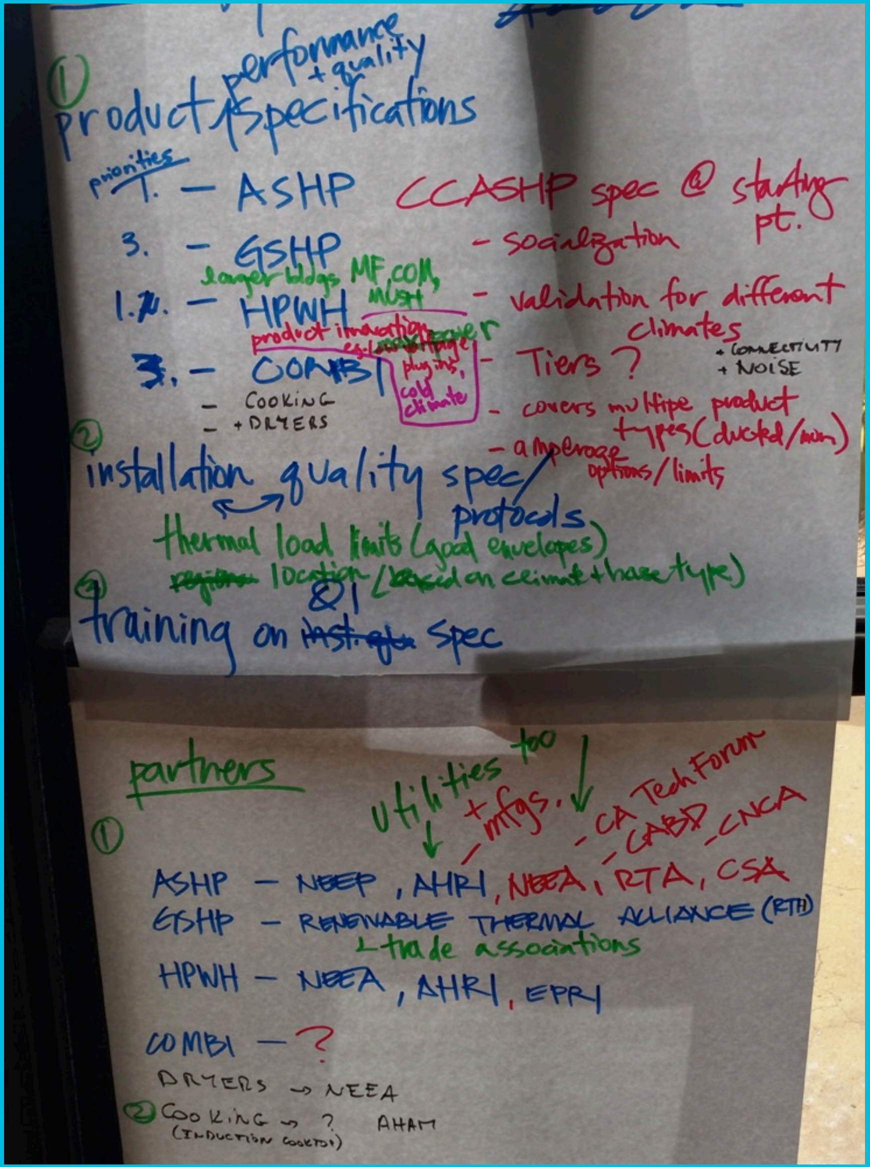
1. Awareness building

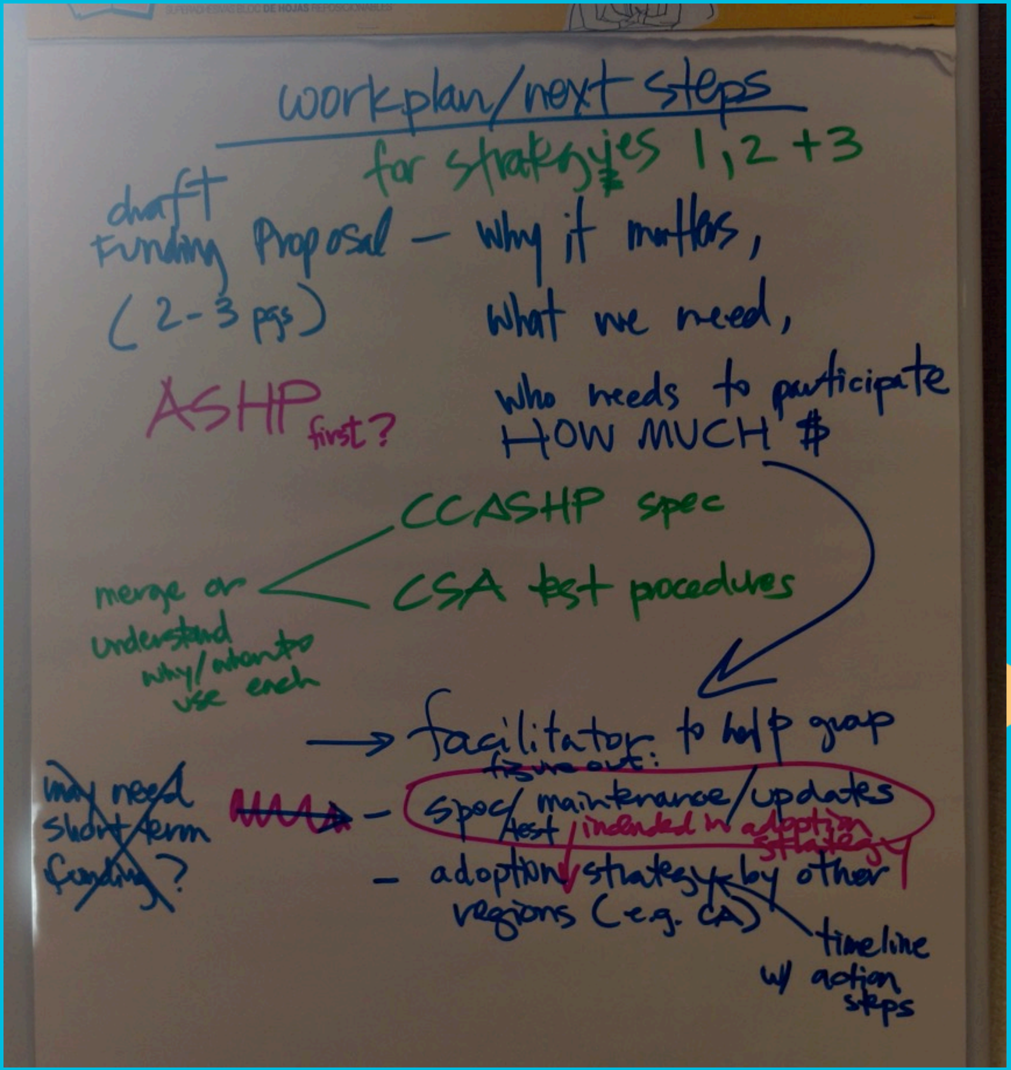


2-3. Existing + New Buildings

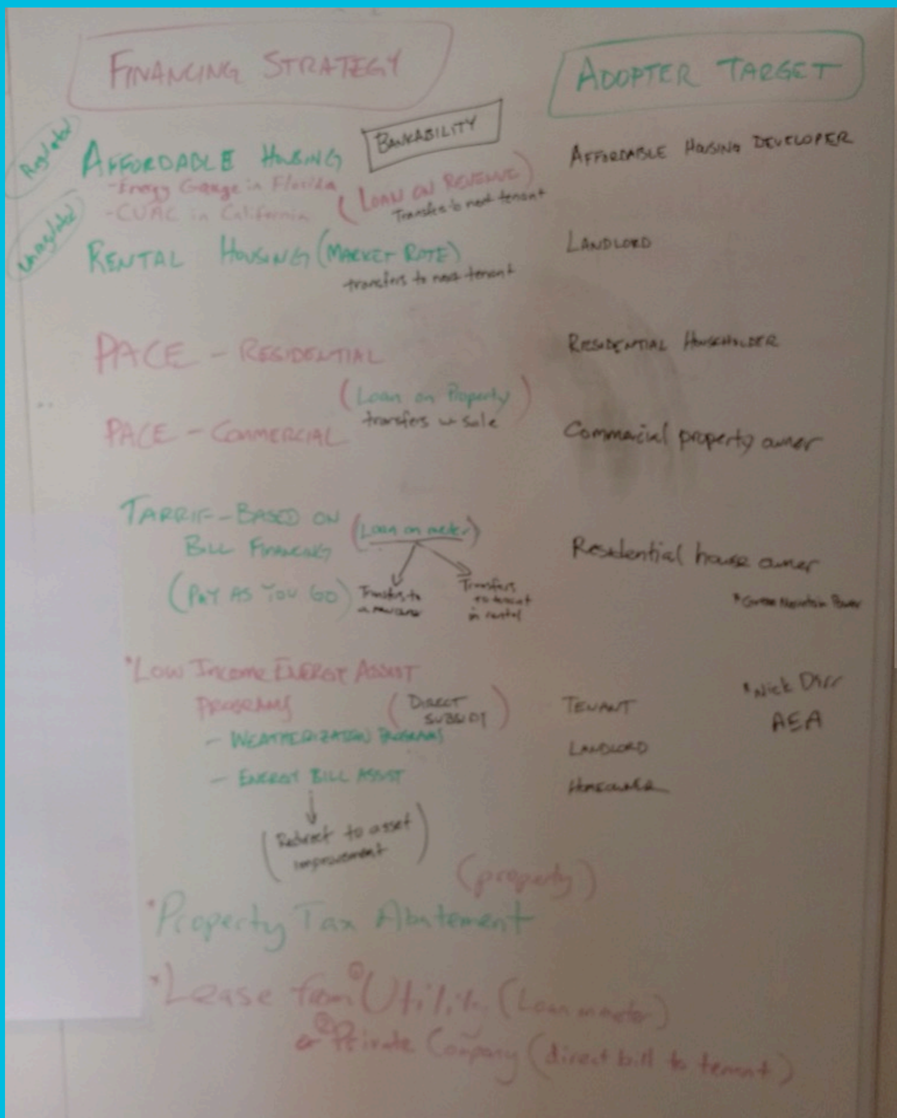


4. Specifications

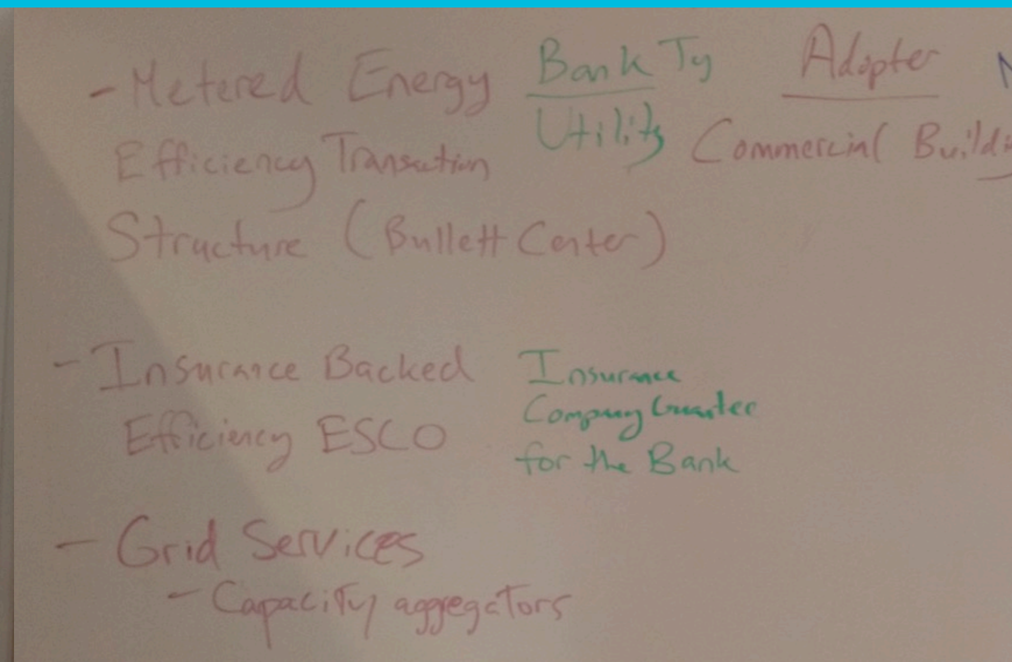




5. Financing



FINANCING STRATEGY
ADOPTER TARGET
BANKABILITY
AFFORDABLE HOUSING
LOAN ON REVENUE
Transfer to next tenant
AFFORDABLE HOUSING DEVELOPER
RENTAL HOUSING (MARKET RATE)
transfers to next tenant
LANDLORD
PACE - RESIDENTIAL
RESIDENTIAL HOUSEHOLDER
(Loan on Property transfers w sale)
PACE - COMMERCIAL
Commercial property owner
TARRIF-BASED ON BILL FINANCING
(Loan on meter)
(PAY AS YOU GO)
Residential house owner
*LOW INCOME ENERGY ASSIST PROGRAMS
(DIRECT SUBSIDY)
TENANT
LANDLORD
HOMEOWNER
AEA
- WEATHERIZATION PROGRAMS
- ENERGY BILL ASSIST
(Redirect to asset improvement)
(property)
*Property Tax Abatement
*Lease from Utility (Loan on meter)
or Private Company (direct bill to tenant)



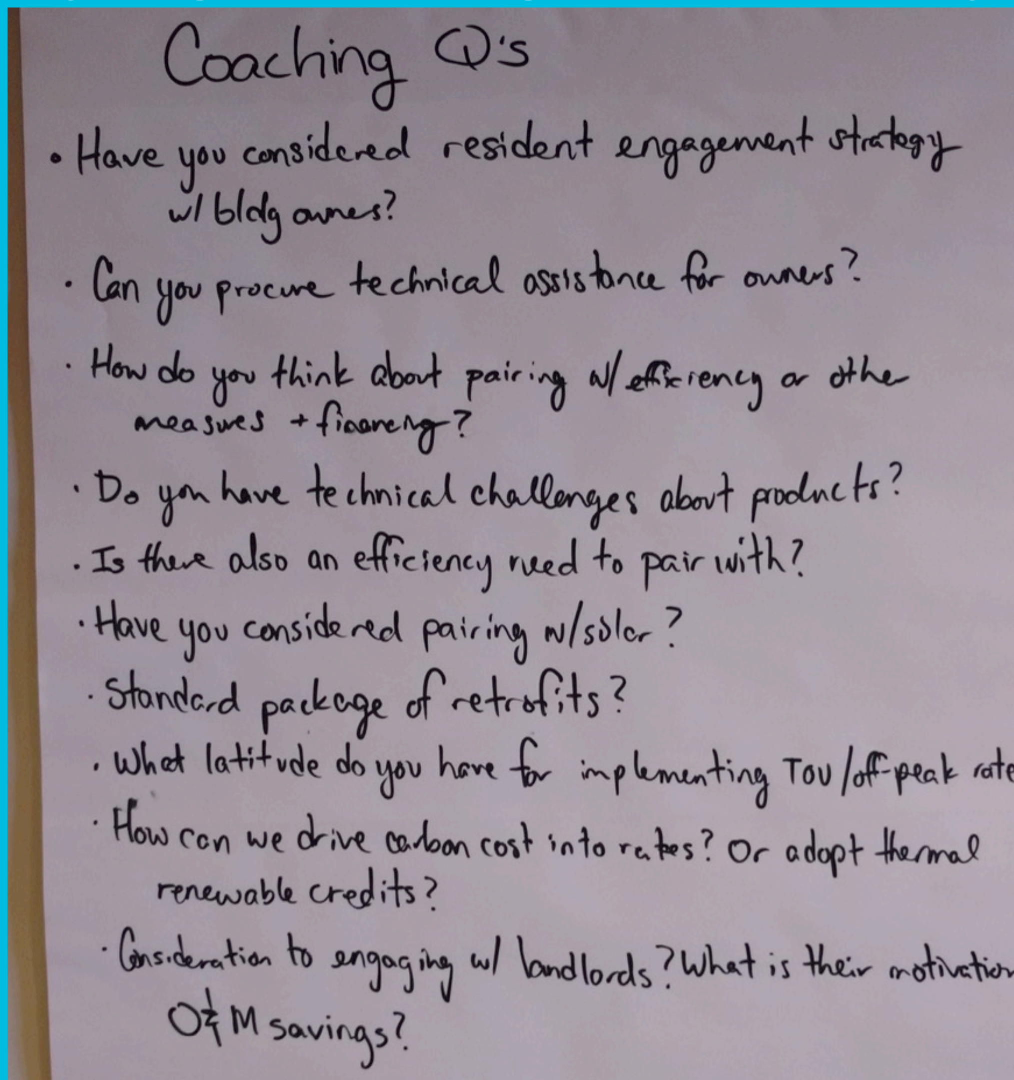
- Metered Energy Efficiency Transaction Structure (Bullett Center)
Utility
Adopter
Commercial Building
- Insurance Backed Efficiency ESCO
Insurance Company Guarantee for the Bank
- Grid Services
- Capacity aggregators

Coaching

Coaching questions we heard from other pods

- Have you thought about new construction with GSHP ground loop installed during construction, as an alternative to NG distribution infrastructure?
- Have you talked about linkages between efficiency in building envelope and ASHP deployment?
- Part of getting to no natural gas requires us to stop investing in gas infrastructure, including transcontinental pipelines as population grows. What's the easiest way to "take back" gas usage place by place?
- Focus on induction vs. gas cooking for consumer interest
- Large parts of California Central Valley that use propane, wood, etc. are low income; high interest among policy makers to improve their quality of life
- Minnesota CEE is releasing a new study detailing performance of cold climate ASHPs across the state – check it out on their website!
- Can financing be addressed with commercial PACE programs – Alaska just passed this for use converting from oil to natural gas
- Consider policy strategies like RPS for thermal technology, and for infrastructure deferral opportunities on gas – non-pipes alternatives. Consider neighborhood approaches that electrify a whole branch of distribution system all at once.
- Any ways to productively engage gas utilities?
- Opportunity to pair residential solar with electrification?
- Opportunity to wire building for electrification at time of panel upgrade or other renovations?

Coaching questions from case clinic on electrifying existing multifamily buildings



Appendix – detailed barriers pictures


Policy, regulatory & utility barriers
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Utilities with low growth forecast have weakening DSM mandates
Policy to focus on Grid connected WH as a requirement
Antiquated- Insufficient Cost Effectiveness Tests
Focus on energy savings rather than emissions, or metrics that account for flexible demand benefits
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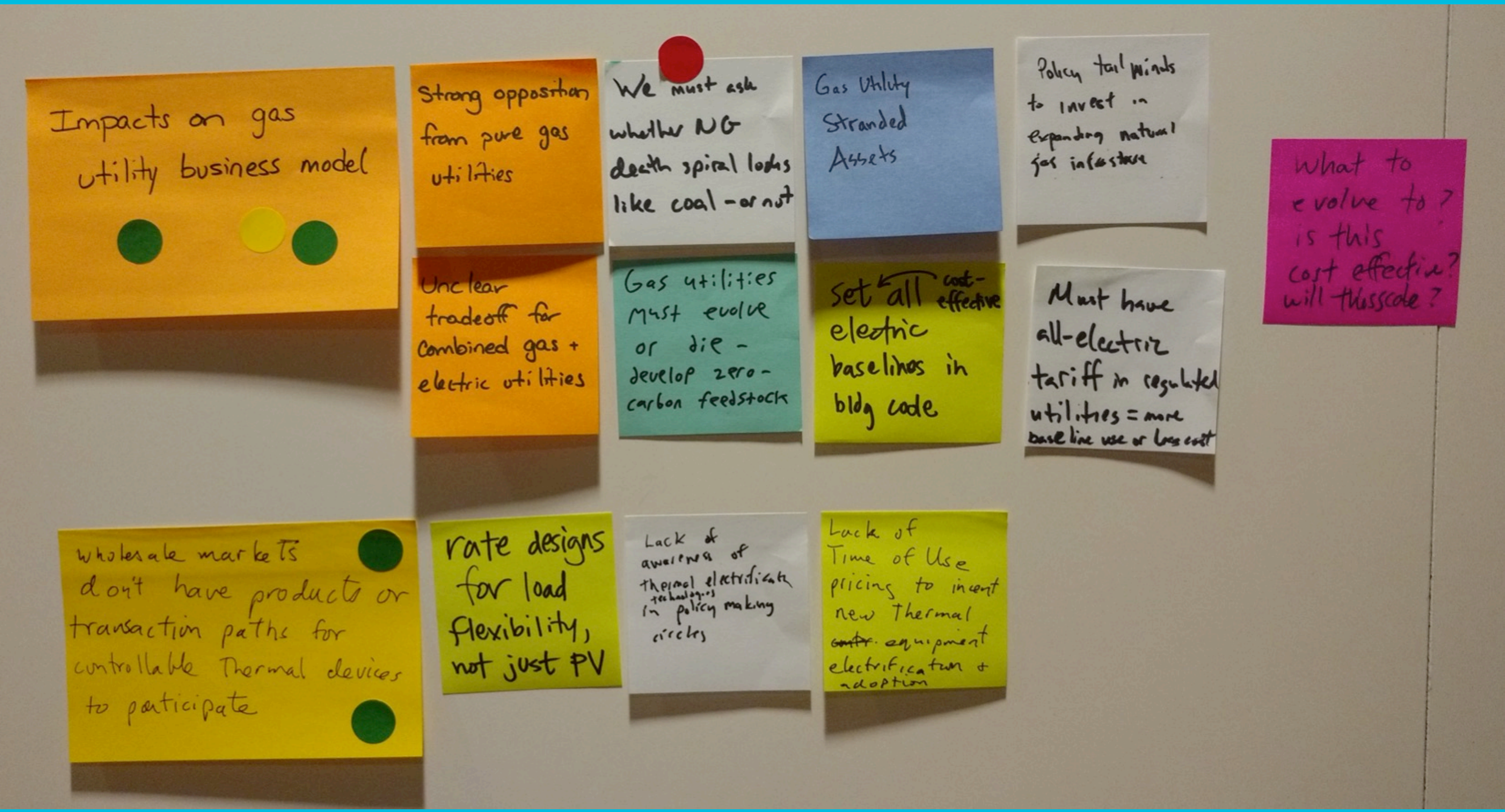

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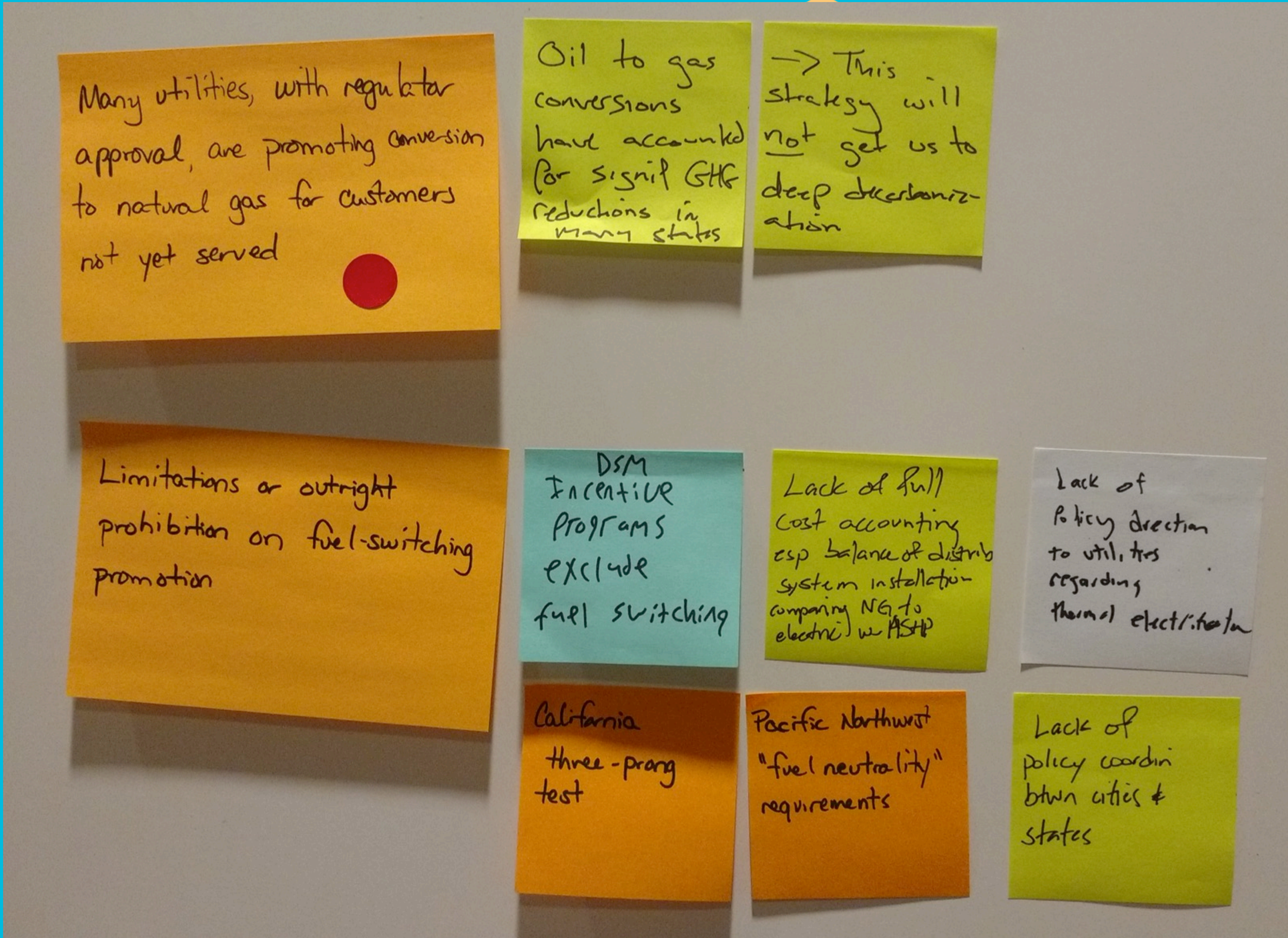
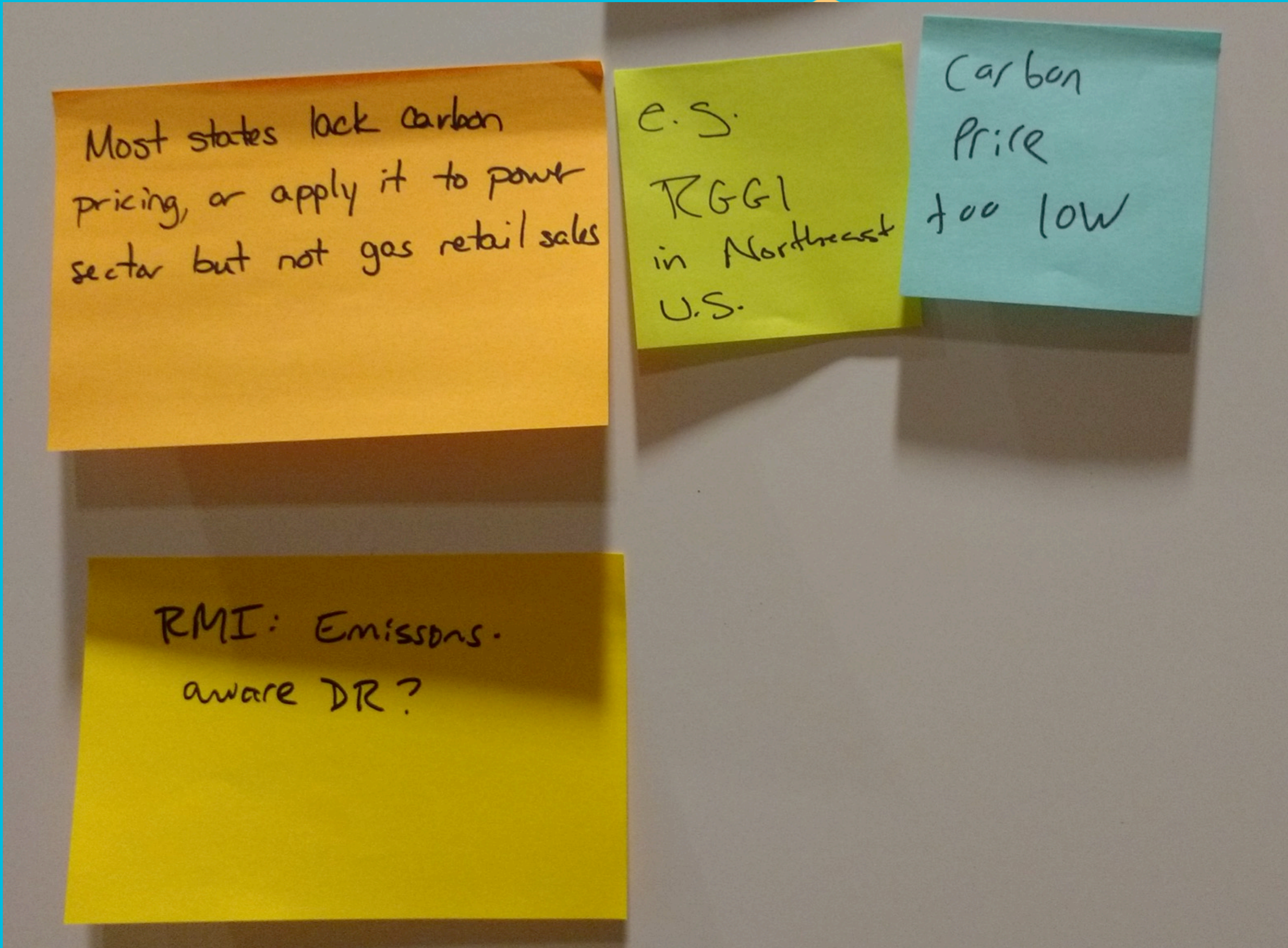
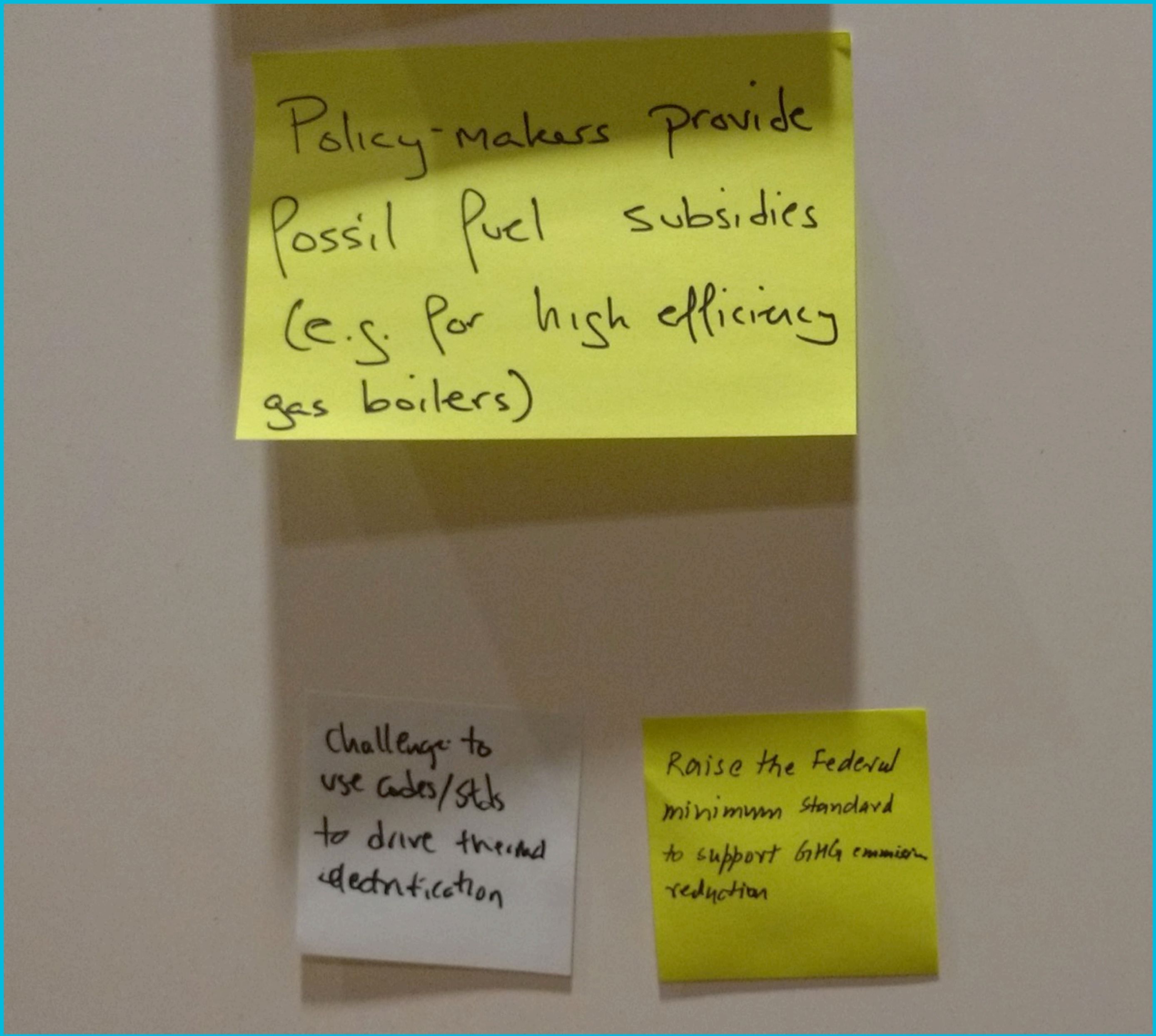
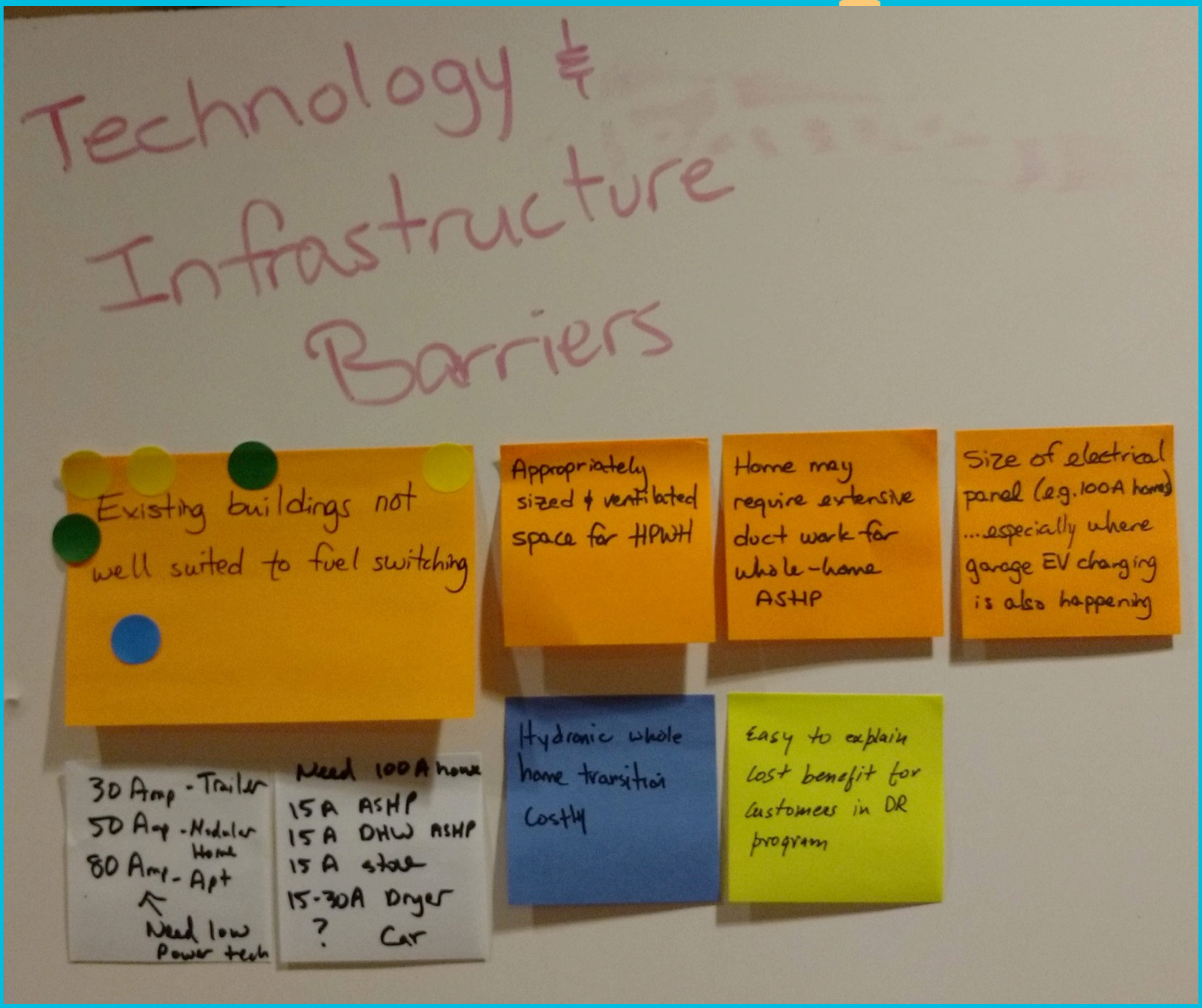
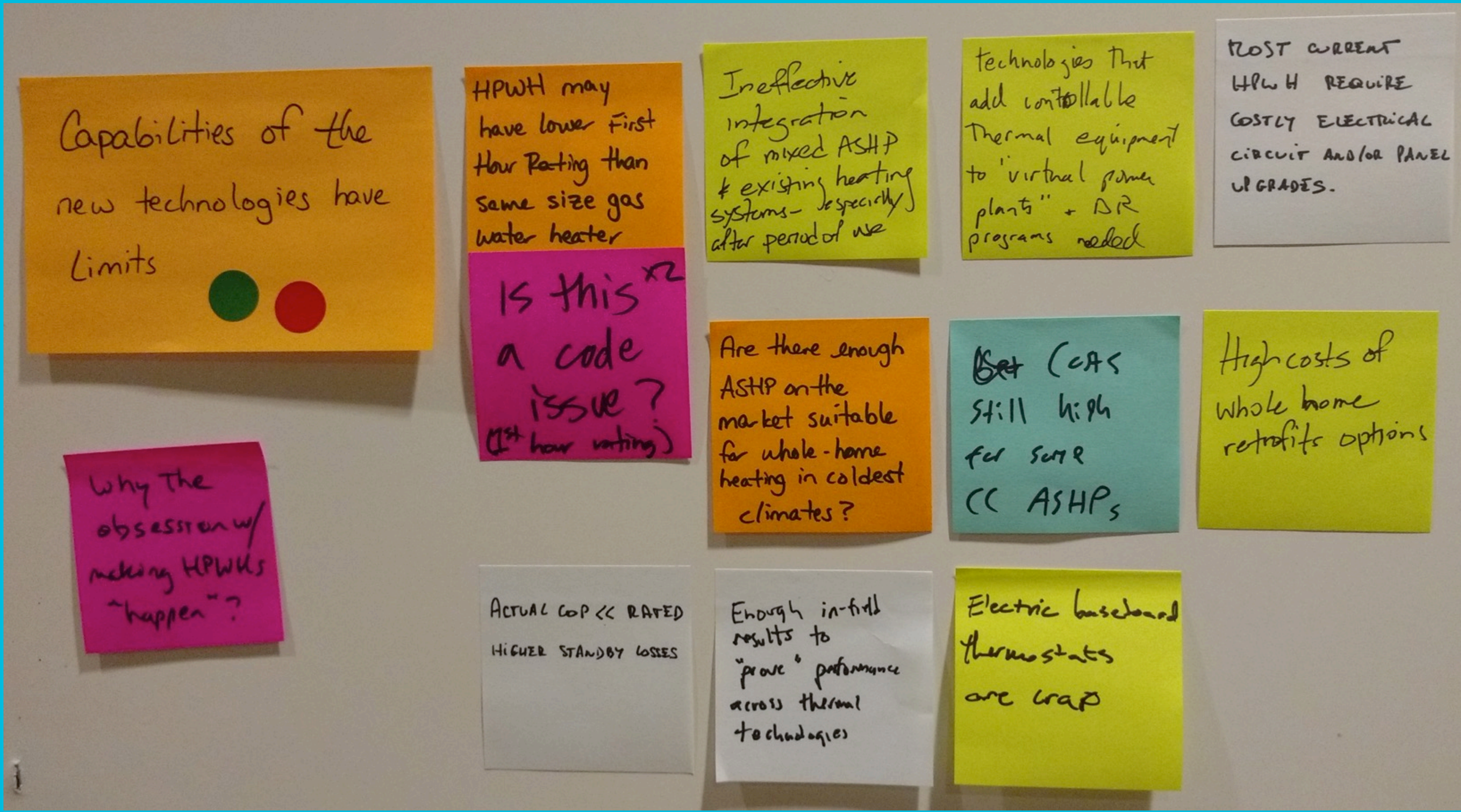
Gas Utility Stranded Assets
Policy tail winds to invest in expanding natural gas infrastructure
What to evolve to? is this cost effective? will this scale?
Unclear tradeoff for combined gas + electric utilities
Gas utilities must evolve or die - develop zero-carbon feedstock
Set all cost-effective electric baselines in bldg code
Must have all-electric tariff in regulated utilities = more base line use or less cost
wholesale markets don't have products or transaction paths for controllable Thermal devices to participate
rate designs for load flexibility, not just PV
Lack of awareness of thermal electrification technologies in policy making circles
Lack of Time of Use pricing to incent new Thermal ~~contr.~~ equipment electrification & adoption

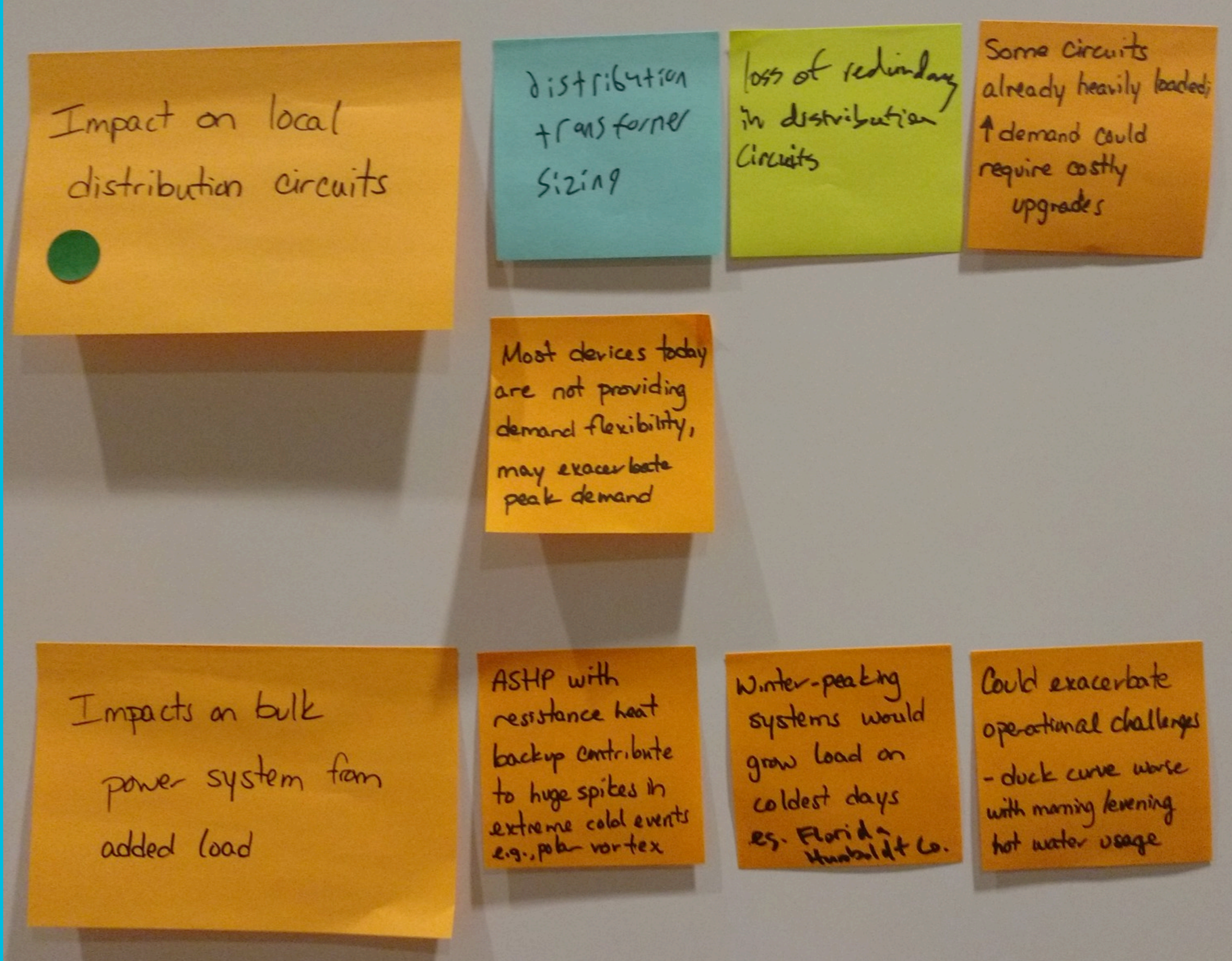

Many utilities, with regulator approval, are promoting conversion to natural gas for customers not yet served
Oil to gas conversions have accounted for signif GHG reductions in many states
→ This strategy will not get us to deep decarbonization
Limitations or outright prohibition on fuel-switching promotion
DSM Incentive Programs exclude fuel switching
Lack of full cost accounting esp balance of distrib system installation comparing NG to electric w ASHP
Lack of Policy direction to utilities regarding thermal electrification
California three-prong test
Pacific Northwest "fuel neutrality" requirements
Lack of policy coordin btwn cities & states

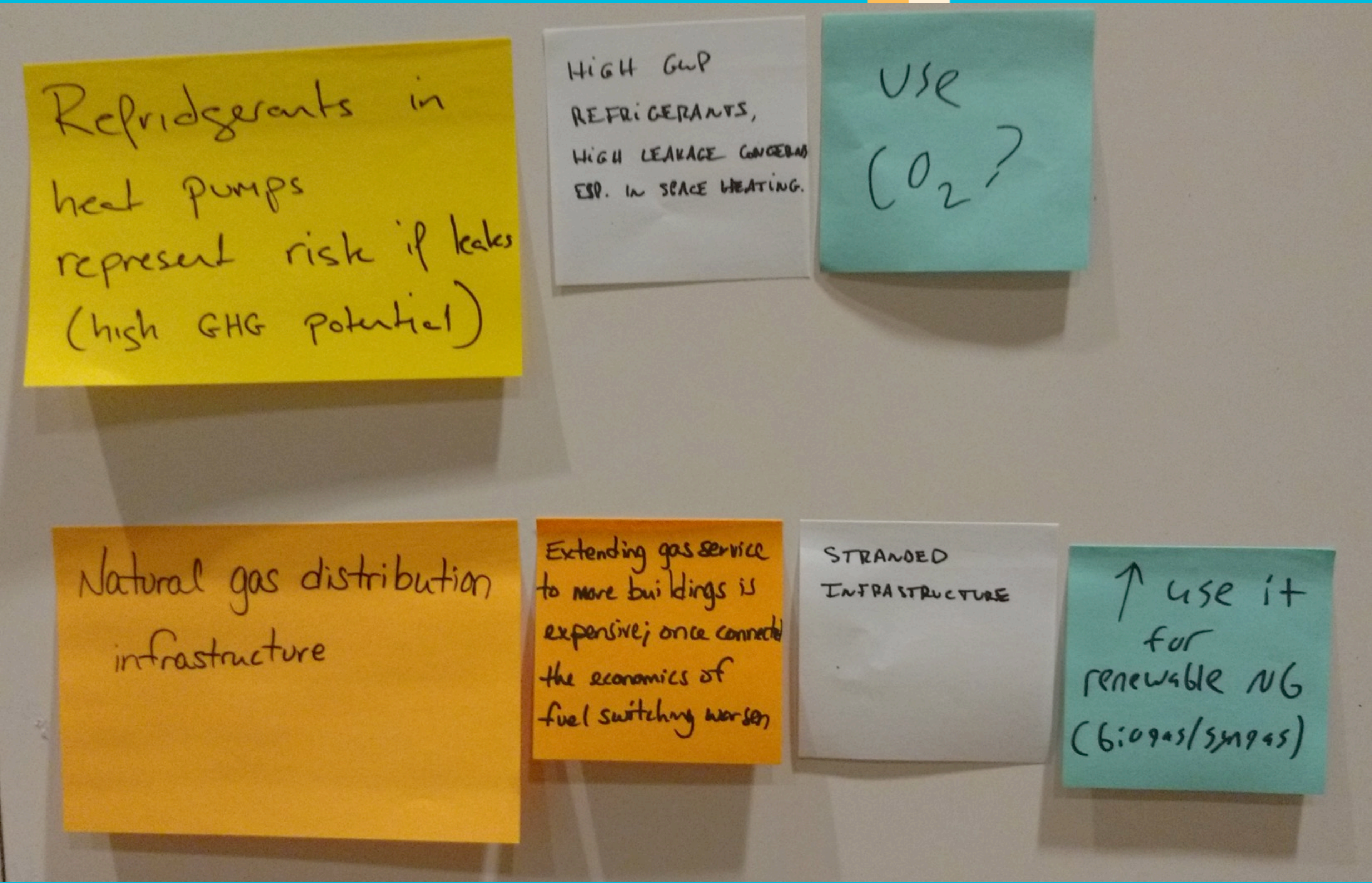

Most states lack carbon pricing, or apply it to power sector but not gas retail sales
e.g. RGGI in Northeast U.S.
Carbon Price too low
RMI: Emissons-aware DR?

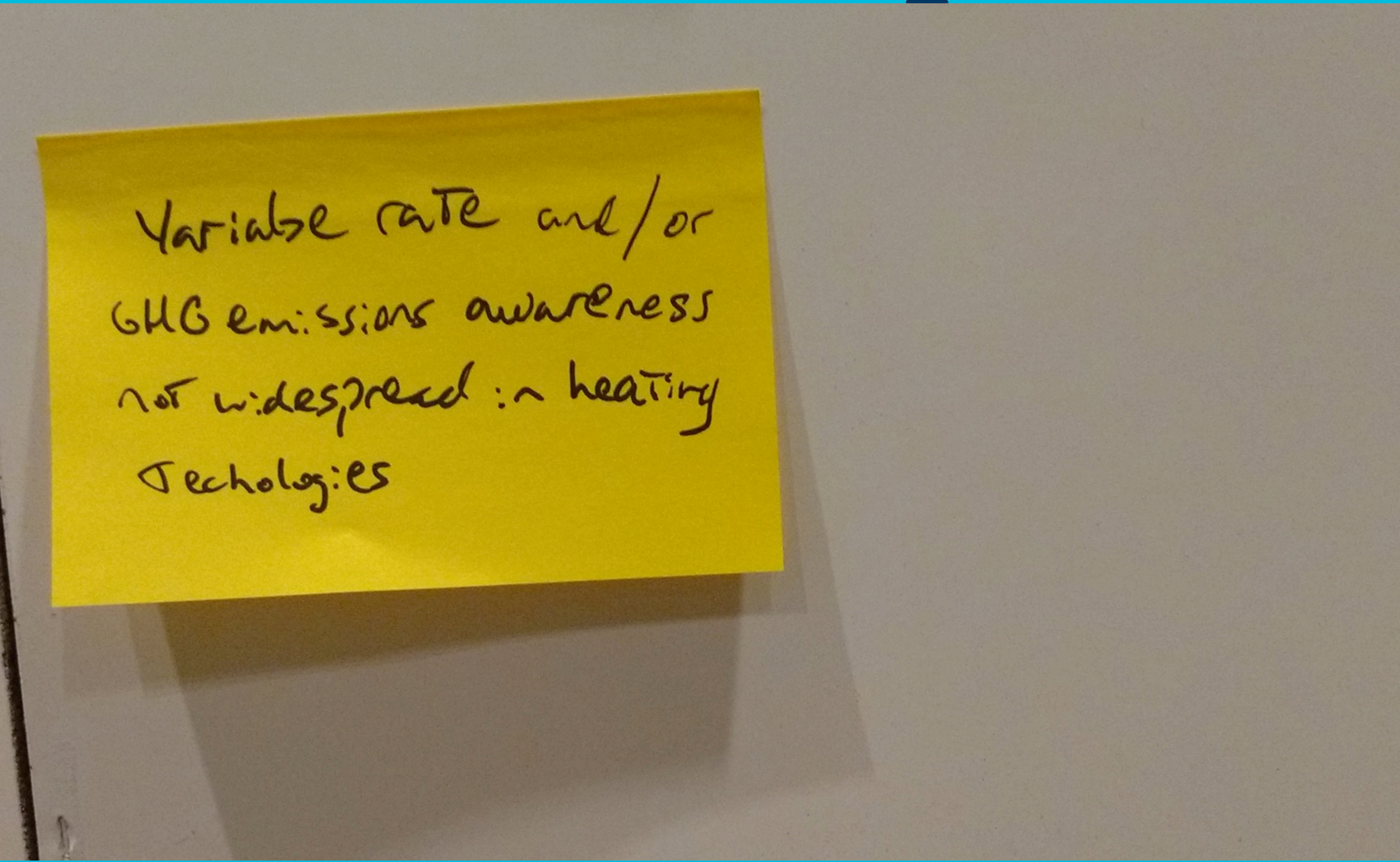

Policy-makers provide fossil fuel subsidies (e.g. for high efficiency gas boilers)
Challenge to use codes/stds to drive thermal electrification
Raise the Federal minimum standard to support GHG emission reduction


Technology & Infrastructure Barriers
Existing buildings not well suited to fuel switching
Appropriately sized & ventilated space for HPWH
Home may require extensive duct work for whole-home ASHP
Size of electrical panel (e.g. 100A homes) ...especially where garage EV charging is also happening
30 Amp - Trailer
50 Amp - Modular Home
80 Amp - Apt
Need low power tech
Need 100A home
15A ASHP
15A DHW ASHP
15A stove
15-30A Dryer
? Car
Hydronic whole home transition costly
Easy to explain cost benefit for customers in DR program

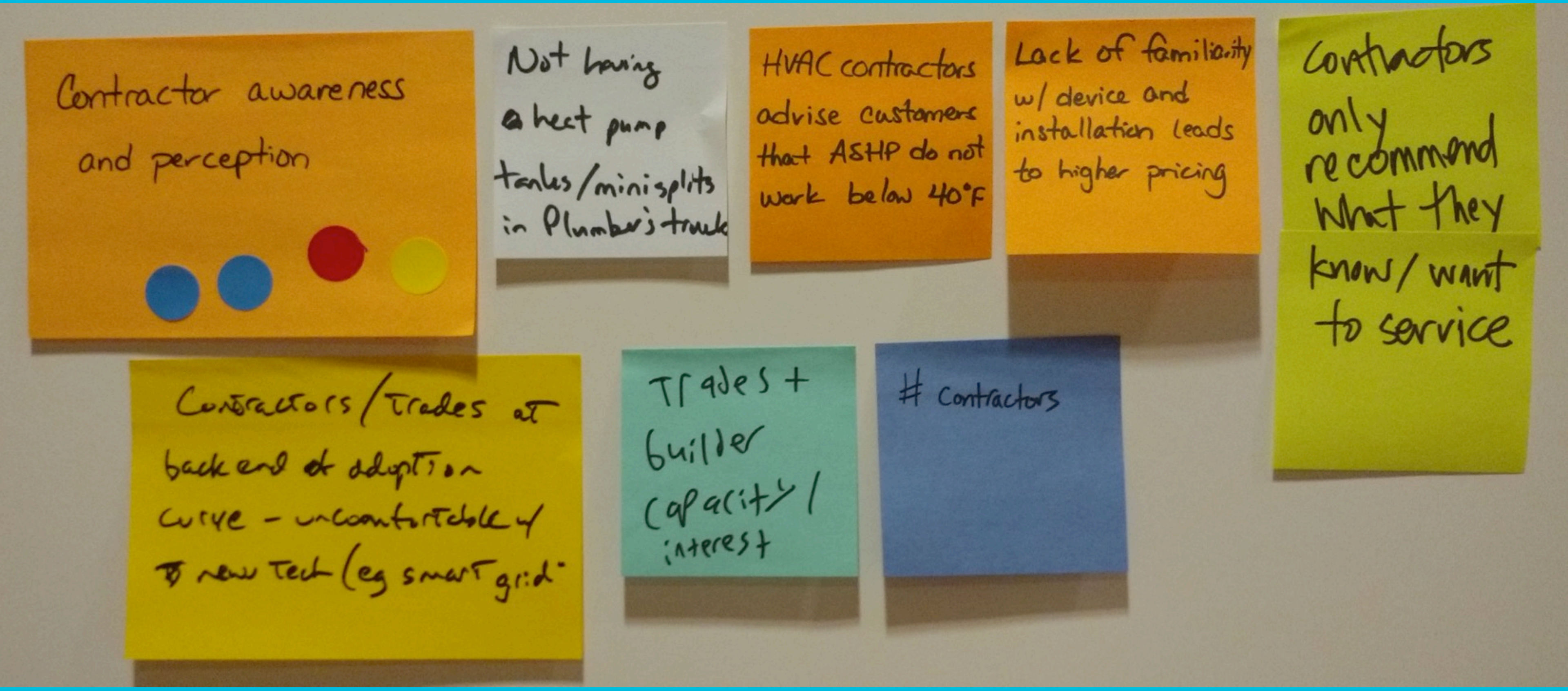

Capabilities of the new technologies have limits
HPWH may have lower First Hour Rating than same size gas water heater
Is this a code issue? x2 (1st hour rating)
Ineffective integration of mixed ASHP & existing heating systems - (especially after period of use)
technologies that add controllable thermal equipment to "virtual power plants" + DR programs needed
MOST CURRENT HPWH REQUIRE COSTLY ELECTRICAL CIRCUIT AND/OR PANEL UPGRADES.
Why the obsession w/ making HPWHs "happen"?
Are there enough ASHP on the market suitable for whole-home heating in coldest climates?
~~Set~~ CCAS still high for some CC ASHPs
High costs of whole home retrofits options
ACTUAL COP << RATED
HIGHER STANDBY LOSSES
Enough in-field results to "prove" performance across thermal technologies
Electric baseboard thermostats are crap

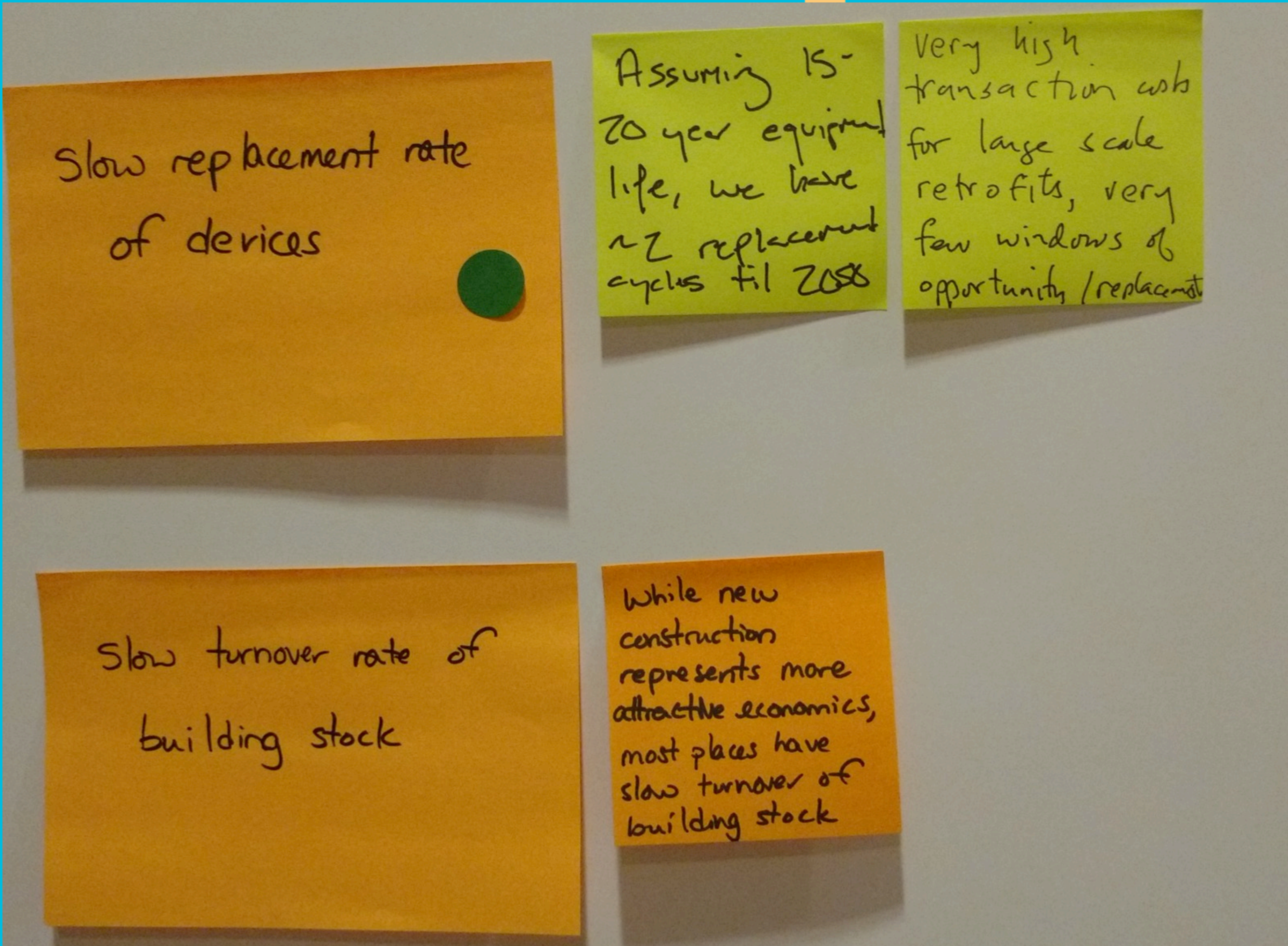

Impact on local distribution circuits
distribution transformer sizing
loss of redundancy in distribution circuits
Some circuits already heavily loaded; ↑ demand could require costly upgrades
Most devices today are not providing demand flexibility, may exacerbate peak demand
Impacts on bulk power system from added load
ASHP with resistance heat backup contribute to huge spikes in extreme cold events e.g., polar vortex
Winter-peaking systems would grow load on coldest days eg. Florida Humboldt Co.
Could exacerbate operational challenges - duck curve worse with morning/evening hot water usage

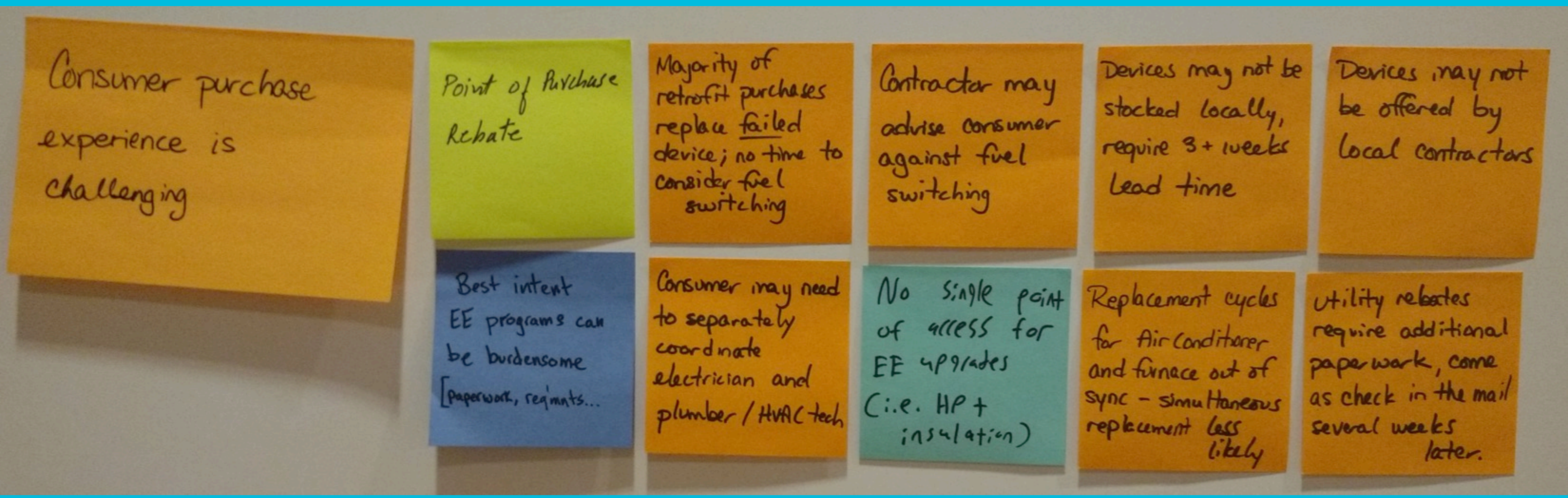

Refridgerants in heat pumps represent risk if leaks (high GHG potential)
HIGH GWP REFRIGERANTS, HIGH LEAKAGE CONCERNS ESP. IN SPACE HEATING.
Use CO_2?
Natural gas distribution infrastructure
Extending gas service to more buildings is expensive; once connected the economics of fuel switching worsen
STRANDED INFRASTRUCTURE
↑ use it for renewable NG (biogas/syngas)

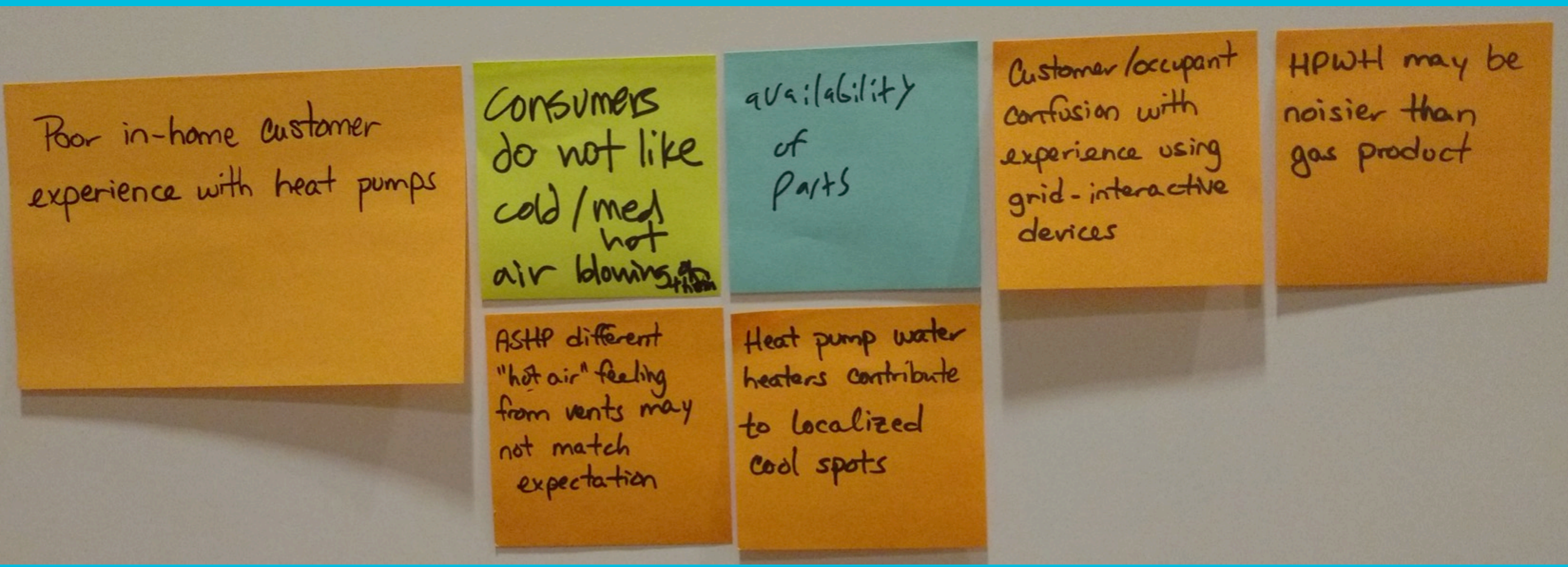

Variabe rate and/or
GHG emissions awareness
not widespread in heating
techologies


Social + Market Barriers
Consumer awareness and perception
Perception that heat pumps are not suitable for cold climates
Consumer perception that electric heating is more expensive than gas
Effort required to learn about new tech is low on consumers priorities
PEOPLE'S HAVE A BETTER PERCEPTION OF GAS THAN ELEC. (DUE TO COST?) + "CLEAN NAT GAS"
People don't know induction stoves cook better
Increase awareness of carbon emission by equipment
Some customers prefer gas cooktops preventing them from going all electric home
Lack of awareness among homeowners & building owners
Customer Confusion across electric Thermal Technologies
low awareness
Misinformation spread by gas utils
Induction Cooking Show on TV

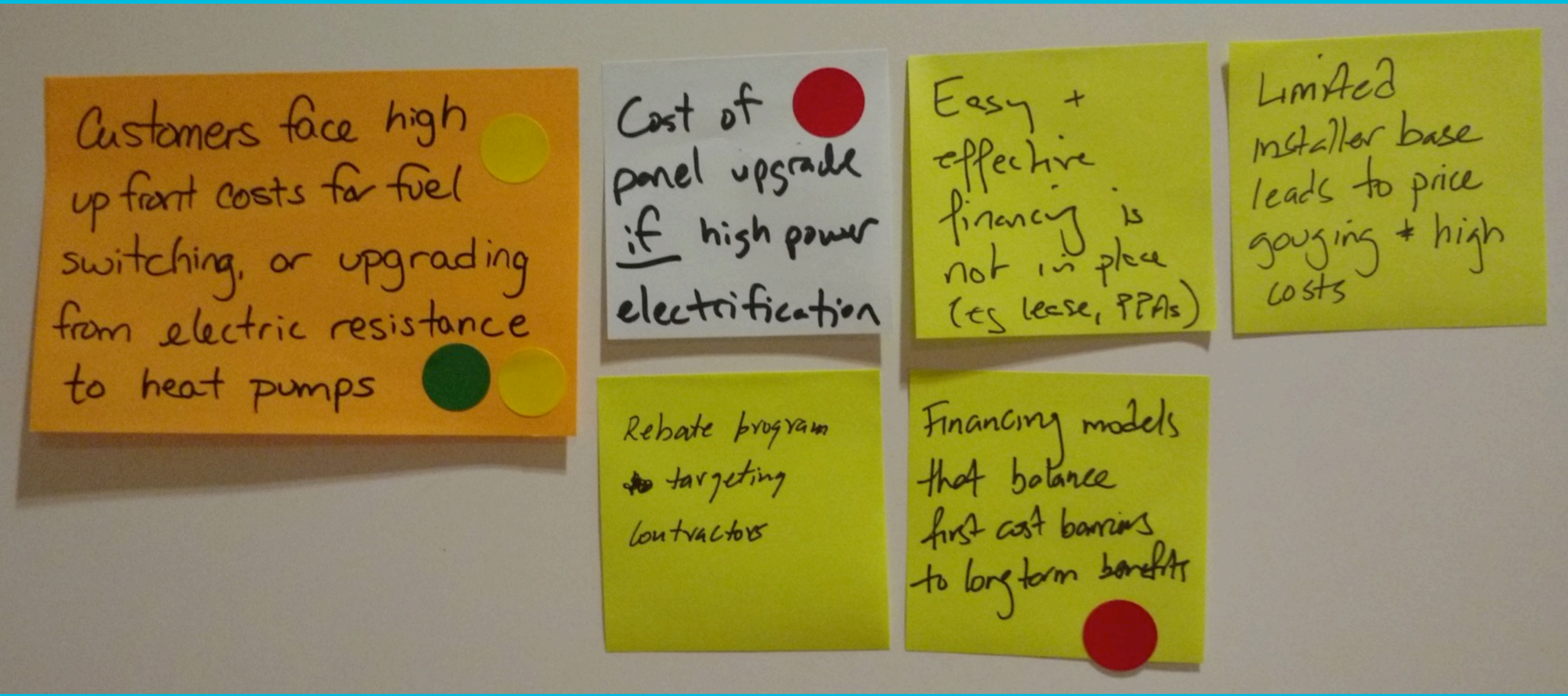

Contractor awareness and perception
Not having a heat pump tanks/minisplits in Plumber's truck
HVAC contractors advise customers that ASHP do not work below 40°F
Lack of familiarity w/ device and installation leads to higher pricing
contractors only recommend what they know/want to service
Contractors/Trades at back end of adoption curve - uncomfortable w/ new Tech (eg smart grid
Trades + builder capacity/interest
contractors

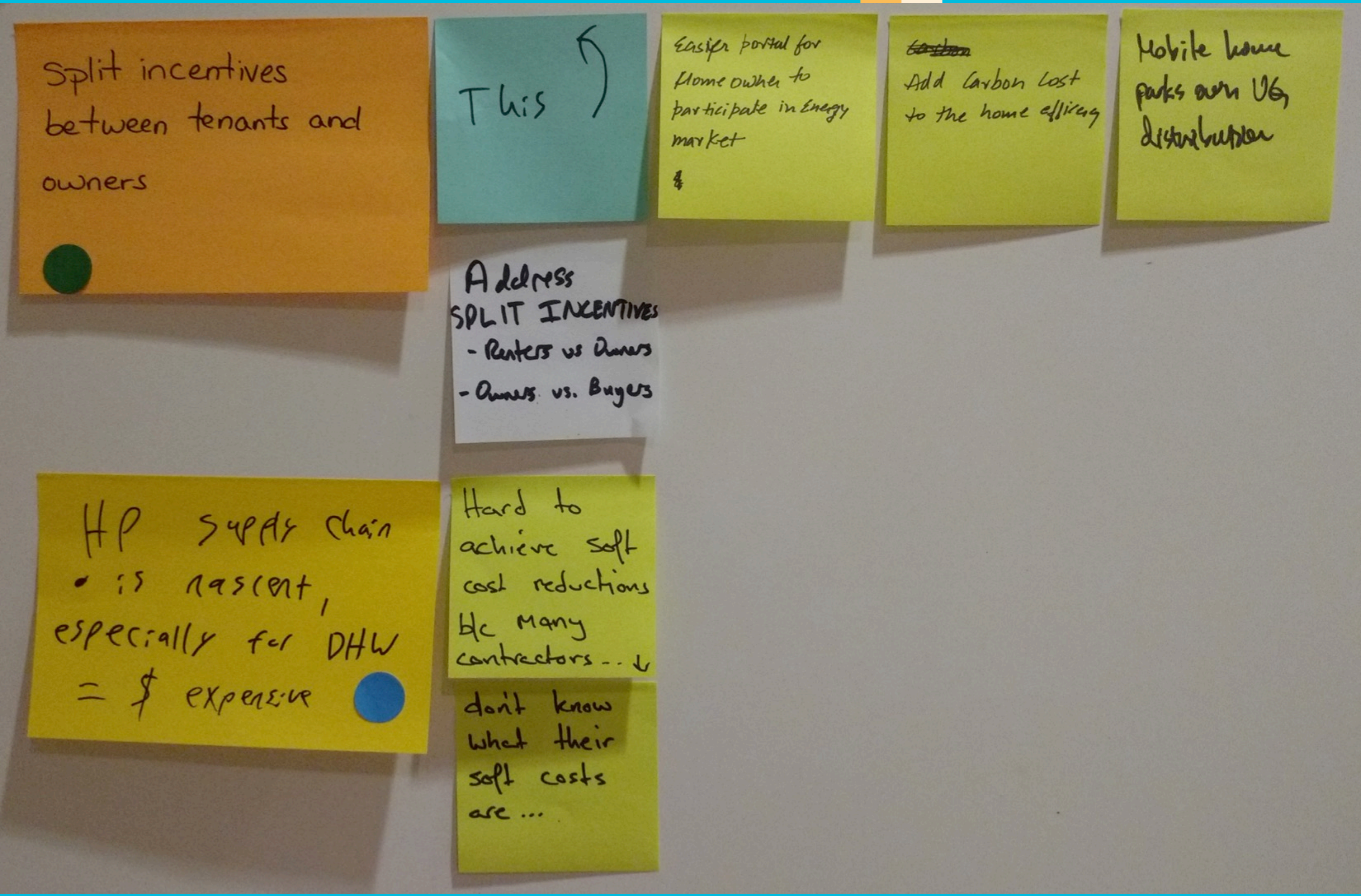

Slow replacement rate of devices
Assuming 15-20 year equipment life, we have ~2 replacement cycles til 2050
Very high transaction costs for large scale retrofits, very few windows of opportunity/replacement
Slow turnover rate of building stock
While new construction represents more attractive economics, most places have slow turnover of building stock

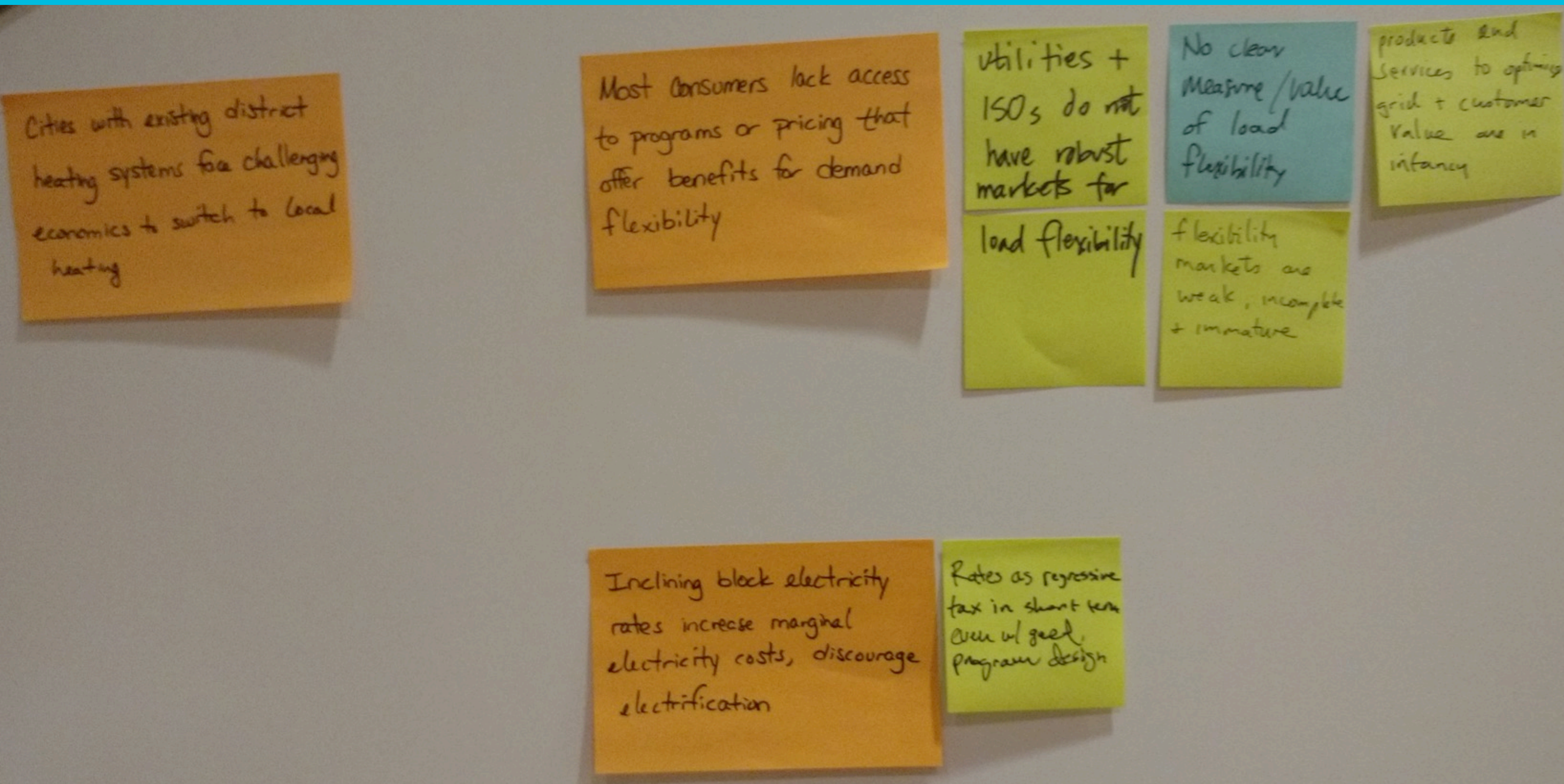

Consumer purchase experience is challenging
Point of Purchase Rebate
Majority of retrofit purchases replace failed device; no time to consider fuel switching
Contractor may advise consumer against fuel switching
Devices may not be stocked locally, require 3+ weeks lead time
Devices may not be offered by local contractors
Best intent EE programs can be burdensome [paperwork, req'mnts...
Consumer may need to separately coordinate electrician and plumber / HVAC tech
No single point of access for EE upgrades (i.e. HP + insulation)
Replacement cycles for Air Conditioner and furnace out of sync - simultaneous replacement less likely
utility rebates require additional paperwork, come as check in the mail several weeks later.


Poor in-home customer experience with heat pumps
Consumers do not like cold/med hot air blowing
availability of parts
Customer/occupant confusion with experience using grid-interactive devices
HPWH may be noisier than gas product
ASHP different "hot air" feeling from vents may not match expectation
Heat pump water heaters contribute to localized cool spots


Economic Barriers
Low energy cost savings when compared to cheap natural gas
Electricity pricing 1/3 of gas
Gas cost 1/3 of electricity (B.C.)


Customers face high up front costs for fuel switching, or upgrading from electric resistance to heat pumps
Cost of panel upgrade if high power electrification
Easy + effective financing is not in place (eg lease, PPAs)
Limited installer base leads to price gouging + high costs
Rebate program targeting contractors
Financing models that balance first cost barriers to long term benefits


Split incentives between tenants and owners
This
Easier portal for Home owner to participate in Energy market
$
Add Carbon Cost to the home offering
Mobile home parks own UG distribution
Address SPLIT INCENTIVES
- Renters vs Owners
- Owners vs. Buyers
HP supply chain • is nascent, especially for DHW = $ expensive
Hard to achieve soft cost reductions b/c many contractors...
don't know what their soft costs are...


Cities with existing district heating systems face challenging economics to switch to local heating
Most consumers lack access to programs or pricing that offer benefits for demand flexibility
utilities + ISOs do not have robust markets for
load flexibility
No clear Measure / value of load flexibility
products and services to optimize grid + customer value are in infancy
flexibility markets are weak, incomplete + immature
Inclining block electricity rates increase marginal electricity costs, discourage electrification
Rates as regressive tax in short term even w/ good program design

thank you!

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