Electrification and Decarbonization in the Built Environment, Energy, and Transportation Sectors: Model Structures
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• Submit questions in the Questions window at any time (window view varies by operating system and browser)
• Questions will be answered during the Q&A portion of the webinar
• Contact Josh for webinar questions: josh@clean-coalition.org
Today’s presenters

John Sarter
Program Manager at the Clean Coalition
clean-coalition.org

Panama Bartholomy
Director of the Building Decarbonization Coalition
buildingdecarb.org

Sean Armstrong
Managing Principal of Redwood Energy
redwoodenergy.tech
A kiss for a gas cook!
The Gas Cookbook
for Young People
Handsome is and handsome does — that’s the GAS idea!

The new gas cookers make you a better cook because they are so easy to use — and a prouder housewife because they are so attractive to look at.
Natural Gas

Methane

92% to 98%

Methane

Other

NATURAL GAS LIQUIDS | 2 to 7%
CARBON DIOXIDE | 0 to 2%
OXYGEN | 0%
NITROGEN | 0.1 to 1%
HYDROGEN SULFIDES | 0.000001%
Varying amounts of water and sand
METHANE IS

84x more potent than CO₂ in the short run
Leakage Varies by Production Zone
Leakage Attributed to California Natural Gas Demand

<table>
<thead>
<tr>
<th>Region</th>
<th>Portion of CA Supply</th>
<th>Leak Rate Used ( % of Production )</th>
<th>Leak Rate Sources</th>
<th>Total Production in Study Area (Billion Cubic Feet)</th>
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<tr>
<td>Permian</td>
<td>13.0%</td>
<td>2.1% [no range]</td>
<td>Presto 2017</td>
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<tr>
<td>San Juan</td>
<td>3.0%</td>
<td>3.1% [2.6 - 3.5%]</td>
<td>Kort 2014, Frankenberg 2015</td>
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<tr>
<td>Anadarko</td>
<td>13.0%</td>
<td>1.6% [0.6 - 2.0%]</td>
<td>Miller 2013, Presto 2017</td>
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<tr>
<td>Western Canada</td>
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<td>0.8% [no range]</td>
<td>Atherton 2011</td>
<td>961</td>
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<tr>
<td>Rocky Mountains</td>
<td>31.5%</td>
<td>4.1% [1.1 - 5.6%]</td>
<td>Petron 2014, Robertson 2017</td>
<td>600</td>
</tr>
<tr>
<td>Southwest Wyoming</td>
<td>26.0%</td>
<td>0.38% [0.12 - 0.86%]</td>
<td>Brentley 2014, Robertson 2017</td>
<td>516</td>
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<tr>
<td>California</td>
<td>10.0%</td>
<td>CEC full lifecycle used</td>
<td>CEC Study</td>
<td>Lifecycle used.</td>
</tr>
</tbody>
</table>

3.6% [2.4 - 4.3%]
Gas Watchdog
@GasWatchdog

Nat gas & methane leaks happen more often than you think. This feed automatically posts news articles on leaks that threaten our safety & health. #GasWatch

Joined April 2018

Tweets 249  Following 7  Followers 303  Likes 2

Who to follow

Follow
Jasmine Salazar @jazsailor
Follow
Dana Jones - JVS @diana_jvso
Follow
nanade @nanadebogm

Find people you know
Import your contacts from Gmail

Connect other address books

Trends for you

#WorldRefugeeDay
89K mentions, @GreenForAll and 2 more

#WednesdayWisdom
67K mentions, @GreenForAll and 2 more

Dwight Howard
Hornets finalize a deal to send Dwight Howard to the Nets, ESPN reports

Gas Watchdog @GasWatchdog • 1h

PFA in Hammerfest LNG leak probe
Safety watchdog to investigate incident that resulted in evacuation at Equinor-run plant in northern Norway
upstreamonline.com

Gas Watchdog @GasWatchdog • 2h

Pipeline data sought as Aliso Canyon rebuilds gas storage #gaswatch

CAIRNS, CALIFORNIA: Pipeline data sought at Aliso Canyon.
Cost
Gas Infrastructure Costs

$6,000-$15,000

$7,000 \times 9,897 = \approx 60,000 \text{ families priced out}

$750-$2,400

$270-$850

Every $1,000 increase in house price prevents 9,897 California families from affording

-NAHB, 2019
Electric appliances have similar or lower costs than natural gas appliances.

Replacing natural gas appliances with electric reduces an existing home’s total GHG emissions by 35-66% in 2020 and 55-60% for new homes.
UC Carbon Neutral Buildings Cost Study
Equity
Lifting the High Energy Burden in America’s Largest Cities: How Energy Efficiency Can Improve Low Income and Underserved Communities

Ariel Drehobl and Lauren Ross
CA Residential Gas and Electricity Prices

2012 = 100

Gas: 100, 110, 126, 128, 134
Electricity: 102, 106, 107, 106, 109

+5.9%/y
+1.7%/y

2012 2013 2014 2015 2016 2017

California Gas and Electricity Prices 2012-2017 (EIA)
HOW DO HEAT PUMPS WORK?

HOW AN AIR SOURCE HEAT PUMP WORKS

SUMMER

Refrigerant in outside coil releases heat to the air

Heat from the air is absorbed by refrigerant in indoor coil

WINTER

Refrigerant in indoor coil releases heat into house

Heat from the air is absorbed by refrigerant in outdoor coil

© Collaborative Efficiency
Health
NOx in California

- Power Plants: 18 Tons a Day
- Buildings: 107 Tons a Day
- Light Duty Vehicles: 118 Tons a Day

https://www.arb.ca.gov/ei/emissiondata.htm
Pollutant Exposures from Natural Gas Cooking Burners: A Simulation-Based Assessment
Induction Cooking: Increasing Choice of Top Chefs
### Consumer Reports Prefers Induction

Top 9 Ranges for 2018 were electric, top 2 were Induction

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Model</th>
<th>Rating</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Induction</td>
<td>Kenmore Elite 95073</td>
<td>89</td>
<td>$1,530</td>
</tr>
<tr>
<td>Induction</td>
<td>Kenmore 95103</td>
<td>88</td>
<td>$1,000</td>
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<tr>
<td>Electric Smoothtop</td>
<td>Samsung NE58F9710WS</td>
<td>85</td>
<td>$1,800</td>
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<tr>
<td>Induction</td>
<td>GE Profile PHS930SLSS</td>
<td>83</td>
<td>$2,430</td>
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<tr>
<td>Induction</td>
<td>LG LSE4617ST</td>
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<td>$3,330</td>
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<tr>
<td>Induction</td>
<td>Frigidaire Gallery FGIF3036TF</td>
<td>82</td>
<td>$990</td>
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<tr>
<td>Gas</td>
<td>LG Signature LUTD4919SN</td>
<td>81</td>
<td>$3,000</td>
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</table>
Climate
Buildings represent ~25% of California's GHG emissions today.
Electricity is getting cleaner, moving toward 100% carbon-free by 2045

Source: CA Air Resources Board, Emission Inventory 2018. 
Building emissions > all in-state power plants

**Emissions by Economic Sector**

- 41% · Transportation
- 23% · Industrial
- 8% · Agriculture
- 6% · Electricity imports
- 10% · Electricity in state
- 7% · Residential
- 5% · Commercial
<1% · Not Specified

**429.4 MMTCO₂e**
2016 TOTAL CA EMISSIONS
Electric Heat Offers Pathway To Zero Emissions

Annual Greenhouse Gas Emissions from Energy Use

Of Title 24 2019-Compliant Building

NRDC analysis, climate zone 13 (Fresno) with rooftop solar. Including methane leakage
Electric Buildings are …

Cheaper
More Equitable
Healthier
More Climate Friendly
Safer
New homes will no longer be heated by gas from 2025, government says

Fossil fuel heating systems banned in bid to tackle emissions

Chiara Giordano | Wednesday 13 March 2019 22:52 | 177 shares | 18 comments

The Netherlands to go completely gas-free

28 June 2018, National
Deep Decarbonization in a High Renewables Future
Updated Results from the California PATHWAYS Model
Estimated Cost and Available Biomethane Supply to California

Biogas supply & gas demand in 2050

2050 demand with high natural gas efficiency and no building electrification
Current SMUD Electrification Programs

All-Electric New Homes Program

- Up to $5,000 per home
- $500 for pre-wiring (required)
- $1,500 for HPSH
- $1,500 for HPWH
- $1,500 for induction cooktop
Discussion of whether program will require no gas to site

Electrification Focus in Home Performance Program (existing homes)

- Up to $13,750 per home
- $2,500 for wiring and panel upgrades
- $2,500 for HPSH
- $3,000 for HPWH
- $250 for induction cooktop
- $3,000 for insulation and sealing
...and miscellaneous items

Midstream HPWH program under development
CPUC Decarbonization Plans

1. All Electric Rates
2. Resource Acquisition:
   - Incentives (eg Rebates)
   - Financing (eg Loans for all-electric customers)
   - Emerging Technology
3. Market Transformation

Overall: Focus goals on GHG emission rather than energy reduction.
California is building the homes of the future, today

Homes built to the new codes will:

- **BE EXTREMELY ENERGY EFFICIENT**
  New homes will feature high efficiency windows, appliances, and lighting and heating.

- **HAVE SOLAR POWER**
  All eligible residential buildings and homes will have access to renewable energy resources, such as rooftop solar.

- **INCENTIVIZE SOLAR + STORAGE**
  In some cases, the rules will allow a limited trade-off between solar + storage and efficiency. The credit is meant to help incentivize on-site energy storage for individual households, an essential tool for achieving emission reductions.

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**Encouraging All-Electric:**
Provisions in the code will encourage more electricity use and all-electric homes to reduce natural gas consumption. Technology such as electric water heaters are becoming increasingly cost effective.
Codes and Standards

The BayREN Codes & Standards Program is a joint effort of the Bay Area cities and counties to increase compliance with the California Energy Code.

FIND OUT MORE
Depreciation

NEXT EXIT
FROM THE ASHES WE WILL RISE
How to Build on Budget in 2020: All-Electric and Solar Powered
The 2020 Residential Code

- World’s Most Efficient Building Code (as was 2016 Code)
- World’s First State/Provincial Code to Mandate PV (2-4kW)
- Still Assumes ~40% Gas Powered Home
Residential Natural Gas Infrastructure Costs and Methane Leakage: $25,000+ per home, 2.7%-5.2% leakage

The total methane leakage rate from California’s residential natural gas infrastructure is estimated to be 4.18% (2.7 – 5.2%). Owner paid cost increases due to more expensive gas appliances and infrastructure additions are in darker blue, while "rate based" cost increases are in lighter blue.

Appliance costs are the marginal cost ($) of gas over all-electric
* heat pump water heater equal in cost to on demand gas water heating
** Aliso Canyon leaked 4.62 Billion cubic feet and alone cost $1.014 billion shared by 5.6 million meters - $181/meter cost (Reuters, Aug 6, 2018)
*** Average of various sources (Cochran 2018, Lennon 2019, SoCalGas 2014, Nemec 2015, Nogueras 2011)
All-Electric Leads Market Growth Since 2010

60+% All-Electric in the South in 2018
Ritz-Carlton Residences, Waikiki
Tourists watching Trump protesters
High variability in daily use among nearly identical households shows opportunities and challenges for savings.
Usage Data on People Living in All-Electric 2020 Code Apartments

Energy Profile for Multifamily Homes in King City, CA

Total Daily kWh

<table>
<thead>
<tr>
<th>Bedrooms</th>
<th>13.6</th>
<th>15.0</th>
<th>17.6</th>
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<tbody>
<tr>
<td>1</td>
<td>0.13</td>
<td>0.16</td>
<td>0.23</td>
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<tr>
<td>2</td>
<td>0.88</td>
<td>0.89</td>
<td>0.90</td>
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<tr>
<td>3</td>
<td>1.12</td>
<td>1.18</td>
<td>1.18</td>
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<td>1.34</td>
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<tr>
<td></td>
<td>5.10</td>
<td>6.08</td>
<td>7.06</td>
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</table>

*Data labels are kWh/day
+Estimated

Legend:
- Dishwasher
- HVAC
- Fridge
- Lighting
- Oven/Range
- Plug Loads
- DHW

Bedrooms:
- 1
- 2
- 3
Variability is high, yet average consumption increases by only 1 kWh/person
“9 out of 10 townhome projects in Vancouver are all electric. At Brixton Flats, our gas utility offered free gas piping throughout the building if the developer had 3 gas loads per suite. But the Developer wanted all electric.”-Chris Higgins, Green Building Planner of Vancouver, BC
Affordable, Quiet and Efficient Heat Pumps

$3k-$6k/Residence

$5k-$13k/Residence

$10k-$20k/Residence
Case Study: Cottages at Cypress, Fort Bragg, CA

- 26 Homes
- 4kW PV/House
- Ductless Minisplit HVAC
- Heat Pump Hot Water
- Electric Resistance Range
- R-49 attic and R-21 Walls
- ALL HERS Inspections
Case Study: Valley View Homes, Selma, CA

PSH18G iQ Drive® | Maytag® M1200 up to 19 SEER, 10 HSPF Heat Pump

Electricity Consumption in a Three Bedroom ZNE Home in Selma, CA: 6650 kWh/yr, ~4kW/roof

- Energy Star Refrigerator: 6%
- HUD Electric Cooking: 13%
- Heat Pump: 18%
- Air Conditioner: 11%
- Lighting: 10%
- HUD Plug Loads: 26%
- Heat Pump Water Heater: 36%
Energy Guide

Water Heater - ELECTRIC
Tank Size (Storage Capacity): 59 gallons
Uniform Energy Factor: 3.7

Rheem Sales Company, Inc.
Model XE95T/CHD56U1
80150

Estimated Yearly Energy Cost

$161

Cost Range of Similar Models
$225 - $732

First Hour Rating
(How much hot water you get in the first hour of use)

very small    low    medium    high
75 Gallons

Estimated Yearly Electricity Use

- Your cost will depend on your utility rates and use.
- Cost range based only on models fueled by electricity with a high first hour rating (75 gallons and over)
- Estimated energy cost is based on a national average electricity cost of 12.00 cents per kWh.
- Estimated yearly energy use: 1341 kWh

www.ftc.gov/energy.

Energy Star

U.S. Government
Federal law prohibits removal of this label before consumer purchase.

Energy Guide

Water Heater - Natural Gas
Tank Size (Storage Capacity): 46 gallons

Model EORHE50
B00037

Estimated Yearly Energy Cost

$231

Cost Range of Similar Models
$225 - $297

First Hour Rating
(How much hot water you get in the first hour of use)

very small    low    medium    high
67 Gallons

Estimated Yearly Energy Use

- Your cost will depend on your utility rates and use.
- Cost range based only on models fueled by natural gas with a high first hour rating (75 gallons and over)
- Estimated energy cost is based on a national average natural gas cost of $1.09 per therm.
- Estimated yearly energy use: 212 therms

www.ftc.gov/energy.
## Builder Models of Electric Radiant Ranges

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<tr>
<th>Brand</th>
<th>Model</th>
<th>Price</th>
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<tr>
<td>Amana</td>
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<tr>
<td>Whirlpool</td>
<td>WFE320M0ES</td>
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<tr>
<td>Frigidaire</td>
<td>FFEF3052TS</td>
<td>$500</td>
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<tr>
<td>GE Appliances</td>
<td>JBS60DKBB</td>
<td>$510</td>
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## Builder Models of Electric Induction Ranges

<table>
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<th>Brand</th>
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<tr>
<td>Kenmore Elite</td>
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<td>Frigidaire</td>
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<td>Samsung</td>
<td>NE58K9560WS</td>
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<td>Electrolux</td>
<td>EI30IF40LS</td>
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</table>
Heat Pumps for Hot Tubs and Swimming Pools

Sizing Tip: 4 BTU/Hr to 6 BTU/Hr per gallon of pool water

Hayward Heat Pro

Pentair

Aquacal Heatwave
Modern Electric Fireplaces

- Dimplex Opti-Myst Pro 1000 ($2099)
- Amantii Zero Clearance ($1,308)
- Napoleon See-thru ($2,008)
- Amantii BI-40-SLIM (In/Out) ($1,618)
- Dynasty DY-BT79 ($1,299)
- Modern Flames CLX Series ($7,449)
- Dimplex Opti-Myst Pro 500 (outdoor) ($1300)
- EnerG+ Patio Heater (outdoor) ($186.99)
- Touchstone Sideline (outdoor) ($574)
- Dimplex Opti-Myst Pro 400 ($1749)
- ClassicFlame Felicity ($349.77)
- Altra Furniture ($160)
North Bay Community Resilience Initiative: Aims

• Track, publicize, and support cutting-edge resilience-creating energy efficiency, electrification, and microgrid incentives, plus policy advancements by SCP, MCE, BayREN, BAAQMD, and others.

• Procure and develop a database of model structures with “Community Microgrid–ready” designs: For new and retrofit residential, commercial, and municipal bldgs.
  • Develop “Electrification & Community Microgrid–Ready” (ECMR) document for homeowners and installers

• Develop Community Microgrid roadmap beginning with critical facility microgrid pilots such as fire stations, hospitals, and places of refuge.
  • Position these pilots in areas that are conducive to expansion into Community Microgrids.

• Develop all as a model for decarbonization and resilience in rebuilding, and for proactive resilience and community modernization.
Developed by the Clean Coalition and a team of industry experts, as a guideline for homeowners, trades installers, and electrical engineers to easily plan and install necessary wiring and communications to be all-electric and community microgrid-ready.
Simple 2 page document

- **Page 1:** Definitions and Operations
  - Connected Appliances
  - Solar/Solare ready
  - Energy Storage
  - Connectivity
  - Additional recommendations
  - Commercial Buildings

- **Page 2:** Wiring for;
  - Connected Appliances
  - Solar/Solare ready
  - Energy Storage
  - Connectivity
  - Additional recommendations
  - Commercial Buildings
ECMR Document Goals: Electrification and Decarbonization through community microgrids

- All-Electric benefits; Safer and healthier homes and communities
  - Elimination of natural gas which is highly flammable, and produces formaldehyde and other toxic gases within the home and community
  - Reduced reliance on outside fuel & energy sources = RESILIENCE
  - Reduction of greenhouse gases
  - EV adoption = Reduction and eventual elimination of all fossil fuels
  - EV’s can become “mobile energy” assets, saving and making money
  - REVENUE for homeowners by using your connected assets as grid assets
ECMR: Staging Community Microgrids

• Microgrid benefits: **Resilient homes and communities**

• Ability to stay powered in grid outages = **Resilience and Security**

• LOCAL Renewable Energy + Storage = **Primary Power**

• Energy produced by local renewable sources = **Permanent local jobs**

• Ability to use behind the meter and community energy storage as “grid balancing assets” *and* revenue stream

• **Elimination of Fossil Fuel “Peaker Plants”**
Model structures: partners

Developing a **design database** for model structures for new and retrofit residential, commercial, and municipal buildings

- In collaboration with high “performance based” building organizations in the USA:
  - Passive House Institute US
  - USGBC / New Buildings Institute “Grid-Optimal”
  - Net Zero Energy Coalition
  - Rocky Mountain Institute
Model Structures: Advanced Energy Rebuild homes

Showcase and provide case studies of homes being rebuilt utilizing the Advanced Energy Rebuild program. Up to $17,500 incentives from Sonoma Clean Power and MCE, to go “all electric” and “microgrid ready”

Having a “microgrid” means when the power goes out, your power stays ON

Sonoma Clean Power currently has 190 homes enrolled and is soon opening their new Advanced Energy Center; A store in downtown Santa Rosa where SCP customers can test and purchase discounted, high efficiency electric appliances.
Model Structures: US DOE Solar Decathlon

NBCRI has partnered with the US DOE Building Technologies Division to showcase and utilize the Solar Decathlon homes for models of rebuilding ZNE homes.

- Bi-Annual competition since 2002 to design, build, and present ZNE homes.
- **Design Challenge**: prepare creative solutions for real-world issues
- **Build Challenge**: Construct Real World projects
Model Structures: Modular and Pre-fab

- Prefabrication = up to 20% reduction in cost and 40% faster!
- Many design options available
- Single Family and Muti-Family
- Increasing number of providers
Sol Lux Alpha

**SOL LUX ALPHA** – First PH Certified multi-unit nanogrid to US market

- 4 unit, 6 story, N+E using only PV within the building envelope
- All electric: Fossil-fuel free
- Passive House PHIUS + US DOE Zero Energy Ready Home program
- (Includes Energy Star, Indoor Air Plus, EPA “WaterSense”)
- **WINNER of the US DOE Housing Innovation Award for Multi-Family**
- **WINNER of 2018 PHIUS “Best overall Project” in North America**

![Image of Sol Lux Alpha building with solar panels on the roof]
Net Positive Energy: How do you get there?

Passive House Baseline + industry best efficient systems
Passive House methodology reduces energy for HVAC by 80%

- Passive Solar design
- Air source heat pumps for HVAC, DHW, Clothes drying
- 100% L.E.D. lighting
- Automatic occupancy and vacancy sensors
- AEK – High efficiency Induction cooktops and Bosch “Benchmark” Appliances
- Next Gen projects - Moving to DC Appliances and systems
Sol Lux Alpha Nanogrid systems

- **Sunpreme** GxB 380w Bifacial panels (up to 25% boost) = 475w

- **Tesla Energy** Powerwall x3 (triple redundancy, 2-3 days energy)

- **Blue Planet Energy** “Blue Ion” for 3 phase loads (elevator & commons)

- **VEHICLE-TO-BUILDING (V2B) ENERGY** enabled
V2B and V2G technologies

**V2B**

(Vehicle to building energy transfer)

- Enables V2G
- Extends **energy** beyond the building
- **Reduces** need for site based Energy Storage System (ESS)
- **Mobile energy assets** for community resilience
Future trends: “Mobile energy” microgrids

Microgrids + bi-directional EV’s = Aggregated “mobile” Community Microgrids

- Solar PV can export to grid or charge EV’s at daytime when solar energy is peaking
  - EV’s can bring that energy “home” and use for residential power at evening/night

- Charge EV’s when rates are low, and use in evening when rates are high (load shifting)

- Once stationary and mobile ancillary ESS grid services are enabled at scale, (and aggregated) fossil fuel peaker plants become unnecessary

- More behind meter ESS + mobile ESS assets results in reduced need for community scale solar / wind + ESS’s

- Greater resilience is created by virtue of distributed systems, and fewer single points of failure

- “Mobile energy” from bi-directional EV’s reduces need for site based ESS & transmission wires

- Add Community Scale R.E. & (mobile) storage at:
  - Points of grid connection to provide ancillary
  - Grid and microgrid services = revenue for the microgrid system
Stationary vs. Mobile

STATIONARY VS MOBILE
Which is better?

OR

OR
Thank you for attending!

Questions?