A Simple Definition for ZNE

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Presentation to CEC

The Definition of Zero Net Energy in Newly Constructed Buildings in California

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www.2020zne.org

McHugh Energy Consultants

Problem Statement

- 2008 EESP developed with goals for res ZNE by 2020 and nonres ZNE by 2030
- Definition of ZNE full of ambiguity
  - OK to have “creative ambiguity” at first so issues can be sorted out but problem when we are half way to 2020 without California sponsored definition and certification.
- Why it is important to have a clear definition of ZNE
  - So brand of ZNE is worth something
    - *Little value if lower performing house can claim ZNE*
    - *Brand undermined by “greenwashing”*
  - So efforts can be coordinated
  - Protects builders when they can point to their house having ZNE certification regardless of what utility bill is.
  - So we can get on with making this goal real.

ZNE Proposal

Clarify goals:

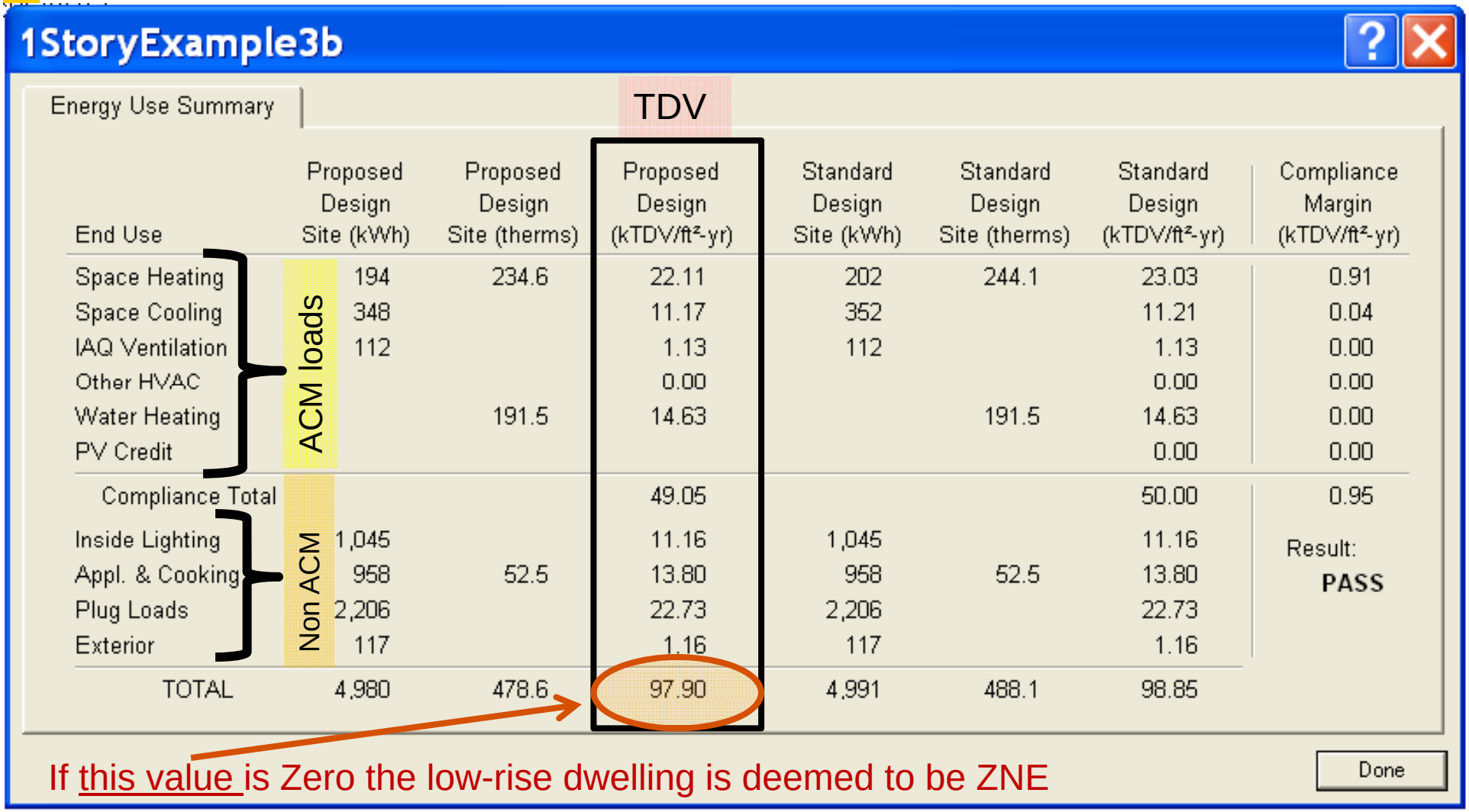
- 1. All new low rise residential construction in California will be zero net energy or equivalent by 2020;
- 2. All new high-rise residential and commercial construction in California will be zero net energy or equivalent by 2030;

Clarify definitions:

- A new Zero Net Energy Home is one which has a CBECC design rating of Zero or less
  - California Building Energy Compliance Calculator
  - CBECC design rating is in TDV units and includes deemed plug loads
- A new Zero Net Energy Low Rise Multifamily Building is one which has a CBECC rating of Zero or less

CBECC (2013 T-24) Software includes non-regulated loads

Screen Shot of One Story Single Family Summary Results



1StoryExample3b

Energy Use Summary

TDV

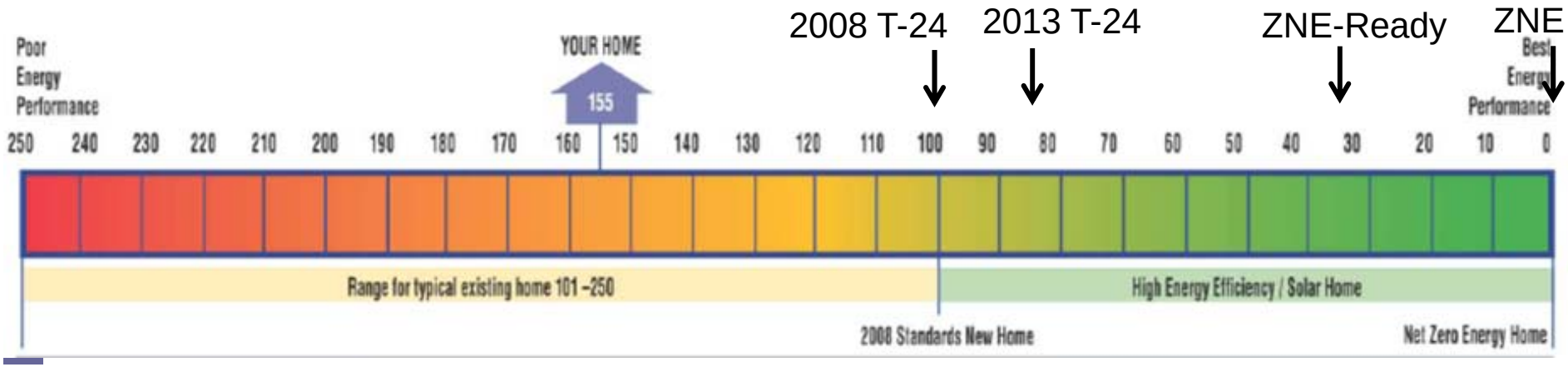
End Use		Proposed Design Site (kWh)	Proposed Design Site (therms)	Proposed Design (kTDV/ft²-yr)	Standard Design Site (kWh)	Standard Design Site (therms)	Standard Design (kTDV/ft²-yr)	Compliance Margin (kTDV/ft²-yr)
Space Heating	ACM loads	194	234.6	22.11	202	244.1	23.03	0.91
Space Cooling	ACM loads	348		11.17	352		11.21	0.04
IAQ Ventilation	ACM loads	112		1.13	112		1.13	0.00
Other HVAC	ACM loads			0.00			0.00	0.00
Water Heating	ACM loads		191.5	14.63		191.5	14.63	0.00
PV Credit	ACM loads						0.00	0.00
Compliance Total				49.05			50.00	0.95
Inside Lighting	Non ACM	1,045		11.16	1,045		11.16	
Appl. & Cooking	Non ACM	958	52.5	13.80	958	52.5	13.80	Result:
Plug Loads	Non ACM	2,206		22.73	2,206		22.73	PASS
Exterior	Non ACM	117		1.16	117		1.16	
TOTAL		4,980	478.6	97.90	4,991	488.1	98.85	

If this value is Zero the low-rise dwelling is deemed to be ZNE

Done

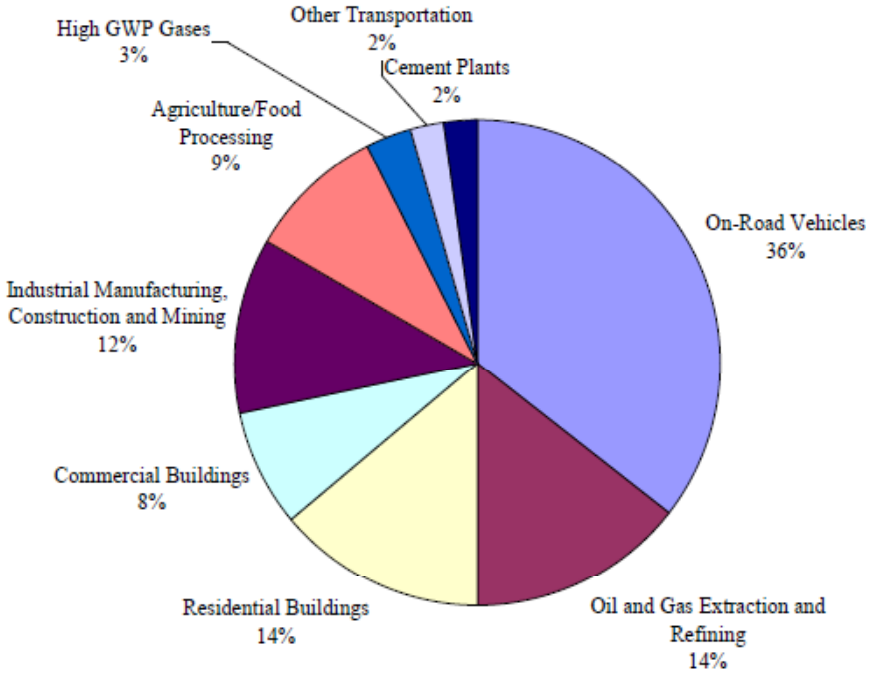
ZNE Definition for Existing Homes

- CA HERS (Home Energy Rating System) Background
  - Whole house rating that includes building measures and plug loads
  - Based on CEC Time Dependent Valuation (TDV)
  - Currently indicates a 0 rating is “Net Zero Energy Home”
- ZNE
  - Infrastructure in place for ZNE existing homes to be based on HERS
    - *However could also be based on CBECC design rating if not trying to get credit for efficient appliances*
  - Includes photovoltaics to offset remaining loads after energy efficiency
  - Should there be a minimum level of efficiency before PV can be applied?
  - Equates to HERS Rating of 0
  - Makes no claims about utility bill being zero as likely some grid access charges levied (similar to renting battery for energy storage)
    - *Clear definition of ZNE from State reduces builder liability*

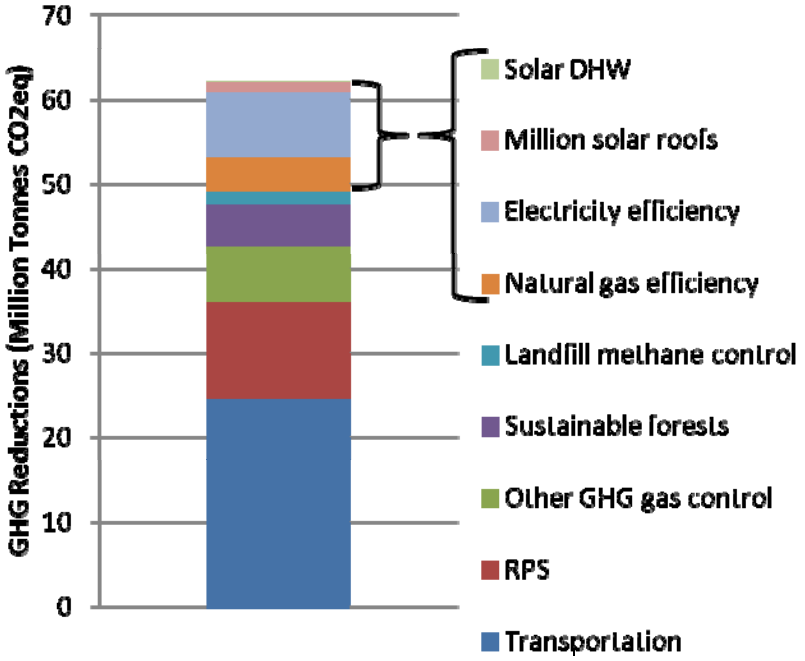


AB32 State Policy: Reduce GHG emissions to 1990 levels by 2020

GHG Emissions by End-use

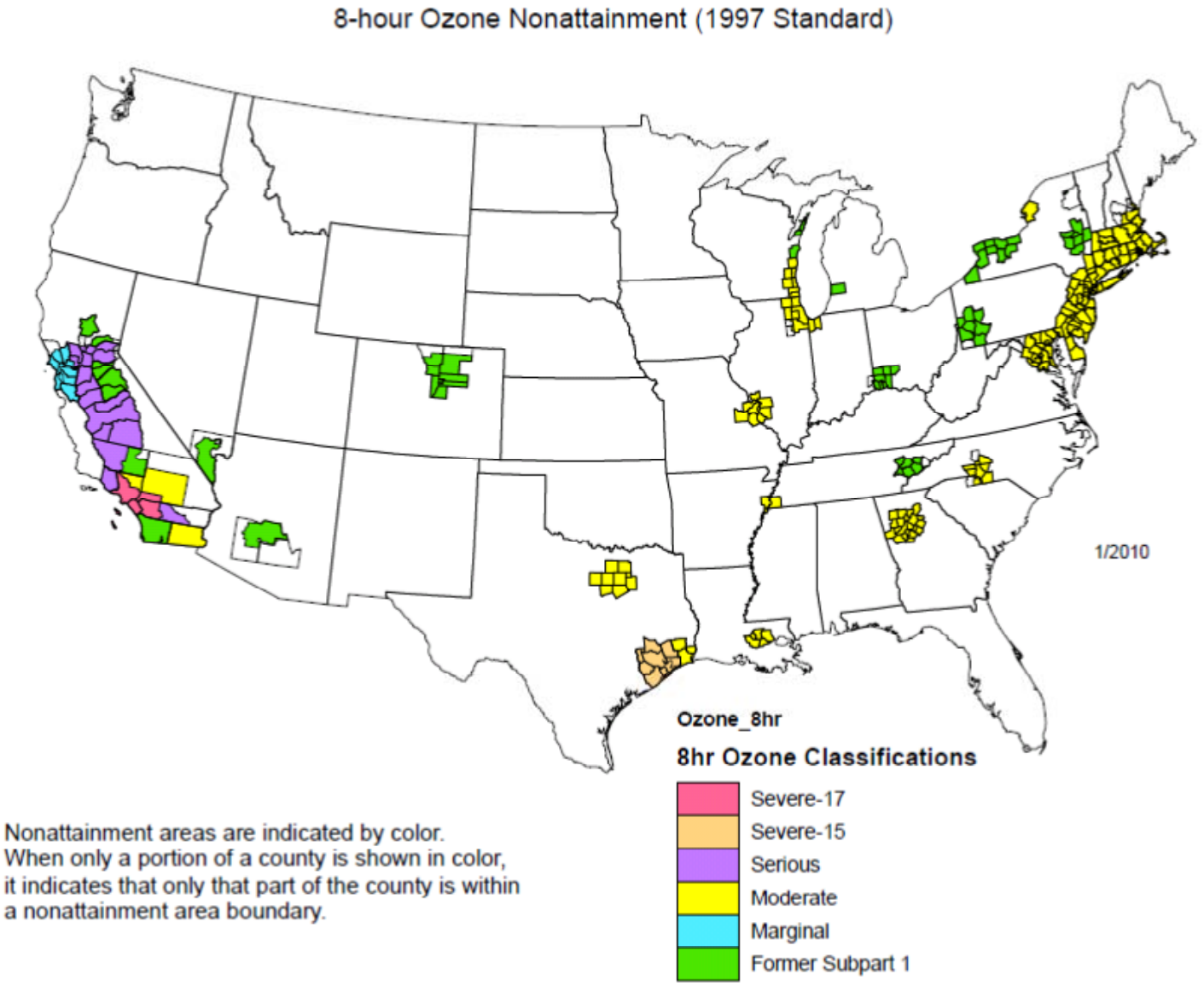


Building measures account for 13.1 Million Tonnes out of 62 Million tonnes reduction or 21% or planned reductions



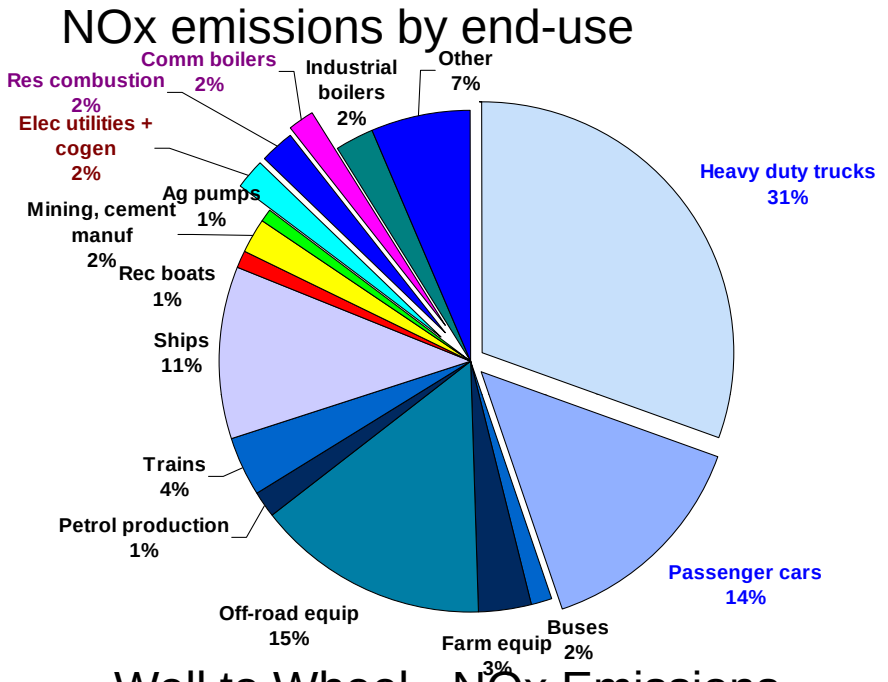
http://www.arb.ca.gov/cc/inventory/data/tables/reductions_from_scoping_plan_measures_2010-10-28.pdf

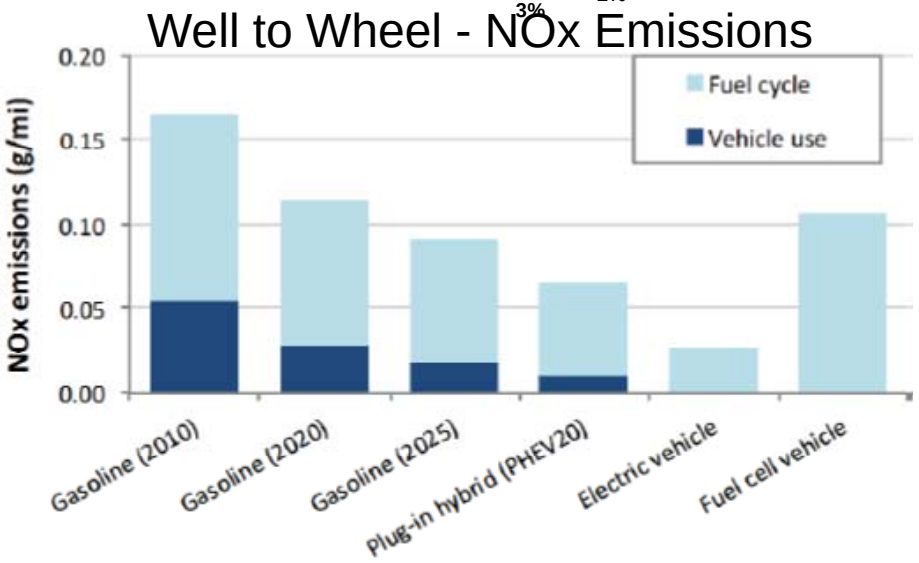
It is not just Carbon: Ozone Pollution
CA is the national leader



Why EV's are key to ZNE future

- Passenger cars are a significant source of NOx.
- Total NOx emissions are least from EV's
- EV's also have one of the least GHG emissions
- Great storage medium – interacts with DR & renewables
- PV & EV together help flatten load profile

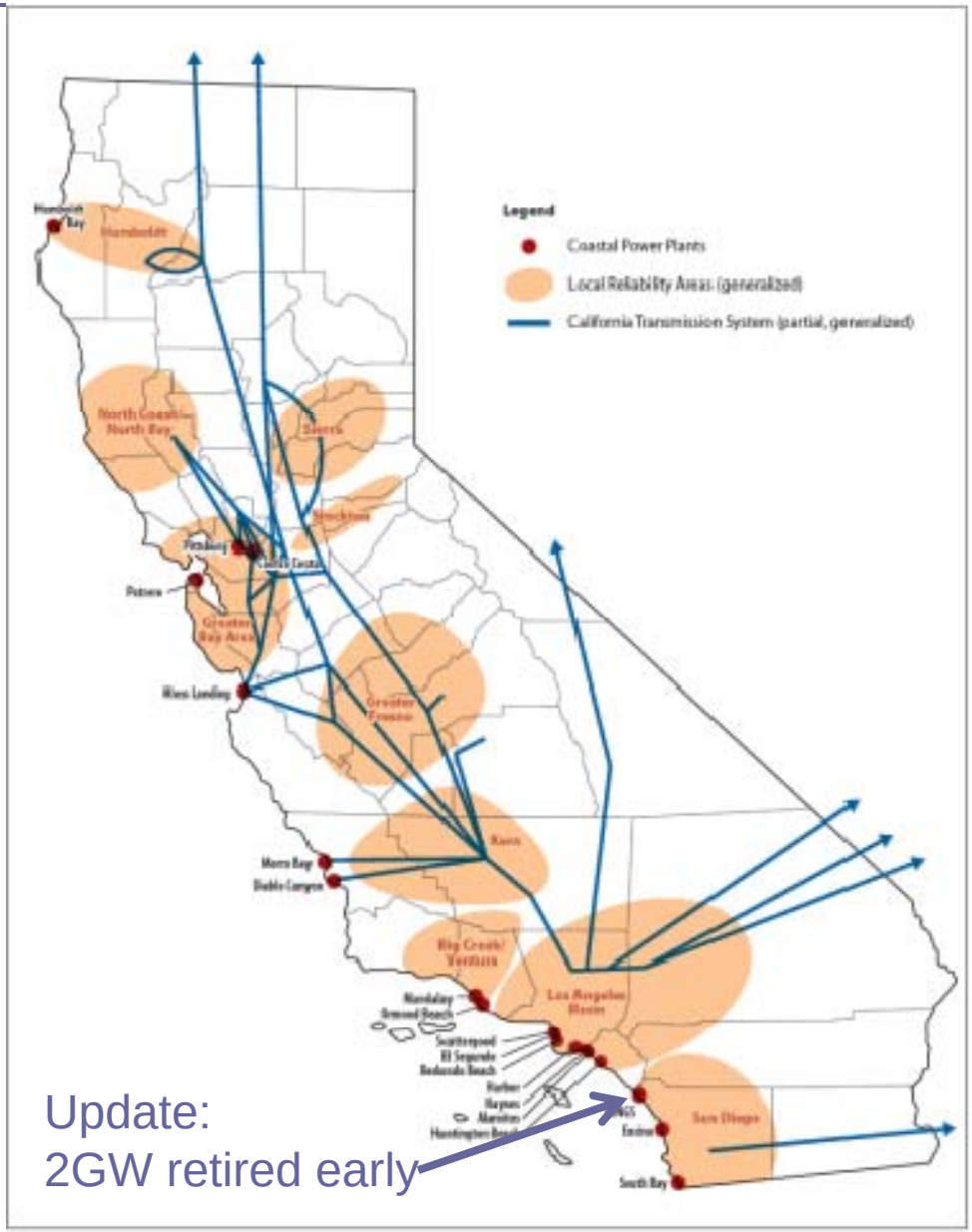




It is not Just Carbon: CPUC Repair vs Displace Decision: Once Through Cooling

- CA Water Control Board Resolution No. 2010-0020
  - phase out once through cooling at 19 plants
  - 21 GW capacity
  - $2.5 million to $108 million per site
- CPUC decisions ahead
  - Relicensing and repair of older plants
  - Population expected to grow between 3.6 Million (9.6%) and 6.9 Million (18%)

http://www.usc.edu/schools/price/futures/pdf/2012_Pitkin-Myers_CA-Pop-Projections.pdf



Does ZNE include plug loads?
If Yes, Importance of T-20 Efforts, Whole Building Rating

Over half of home electricity consumption not covered by T-24

Electricity End-uses

End-Use	kWh/yr	
Not covered by T-24	**3,612**	
Dryer	187	
Clothes Washer	109	
Dish Washer	73	
First Refrigerator	707	
Additional Refrigerator	313	
Freezer	138	**54%**
Range/Oven	105	
Television	645	
Microwave	122	
Home Office Equipment	17	
Personal Computer	602	
Well Pump	28	
Miscellaneous	568	
T-24 + Preempted	**1,106**	
Conv. Space Heating	37	
Heating	13	
Aux Space Heating	0	**10%**
Central Air Conditioning	876	
Room Air Conditioning	47	
Water Heating	133	
T-24	**1,927**	
Furnace Fan	164	
Attic Fan	14	
Evaporative Cooling	43	
Solar Water Heating	0	**29%**
Pool Pump	234	
Spa	25	
Outdoor Lighting	284	
Spa Electric Heat	28	
Lighting	1,136	
Total	**6,645**	

Natural Gas End-uses

End-Use	Therm/yr	%
Not Covered by T-24	**51.4**	
Dryer	16.2	**14%**
Range/Oven	31.7	
Miscellaneous	3.5	
T-24+ preempted	**309.0**	
Primary Heat	175.8	**83%**
Conv. Gas Water Heat	133.2	
T-24	**10.2**	
Pool Heat	5.6	**3%**
Spa Heat	2.9	
Auxiliary Heat	1.6	
Total	**370.5**	

Not Covered by T-24
Plug loads are installed after building inspection and are not covered by T-24

T-24 + Preempted
T-24 is preempted from requiring higher equipment efficiency but T-24 can impact the loads on equipment (envelope eff, controls etc.)

Covered by T-24
Loads and equipment efficiency can be regulated by T-24

*** 2009 Residential Appliance Saturation Survey**

Modify policy: "All new low rise res construction ZNE or equivalent by 2020"

- *Prepare for success not failure*
  - Low rise residential ZNE is technically feasible and…
  - Cost-effective
- Low rise residential matches the current T-24 structure
  - Low-rise residential vs nonresidential and high rise res
- Equivalency: Objective achieved without watering down definition of ZNE.
- Addresses where ZNE is difficult or even undesirable
  - Building a home in the shade of a 300 year old tree.
  - Building an infill project which is shaded by surrounding buildings
- Equivalency can use Std 189.1 approach
  - Equivalent methods allowed only if no solar access
- To maintain ZNE brand, not labeled as "ZNE equivalent" but "code compliant" in 2020

ZNE Technical Potential Study

Single Family Residential Change Log

CZ12 Sacramento

	Strategy *(Baseline is T24 2013 Unless Noted Otherwise)*	kBtu/ft2 savings	TDV$/ft2 (30yr) savings	TDV$ reduction
	Starting EUI:	30.4	18.4	0%
1	Improved Wall Construction: 2x6 walls, R-21 w/ R-4 rigid ext. sheathing. Advanced framing, 24" o.c.	-1.94	-1.15	6%
2	Ceiling Insulation: R-60 blown-in insulation w/ raised heel trusses	-0.43	-0.23	7%
3	Reduced Building Infiltration: 1.8 SLA / 3.15 ACH50	-0.91	-0.24	9%
4	Improved Windows: U-Factor=0.25 / SHGC=0.20	-0.78	-0.16	10%
5	Cool Roof: Reflectivity=0.40 / Emissivity=0.85	0.06	-0.14	10%
6	Additional Thermal Mass	-0.15	-0.20	11%
7	Improved Lighting: High efficacy LED lighting and vacancy controls	-1.32	-2.20	23%
8	High Efficiency Appliances: Clothes washer, Dishwasher, Refrigerator	-1.12	-0.52	26%
9	Reduced Plug Loads & Plug Load Control 20%	-0.71	-1.09	32%
10	Low-Flow Shower & Sinks	-1.84	-0.49	34%
11	Ducts in Conditioned Space	-0.86	-0.54	37%
12	High Efficiency 2-speed AC, SEER 21 w/ Integrated Ventilation Cooling	-0.23	-0.55	40%
13	Condensing Gas Space Heating	-0.78	-0.22	42%
14	Condensing Gas Water Heater	-2.53	-0.85	46%
15	Improved HW Distribution: Compact Design, Insulated HW Pipes	-0.18	-0.06	46%
16	Rooftop PV (see "Solar PV (kW)" in "Building Performance Data" table for PV system sizes)	-16.65	-9.77	100%
	Ending EUI:	0.0	0.00	

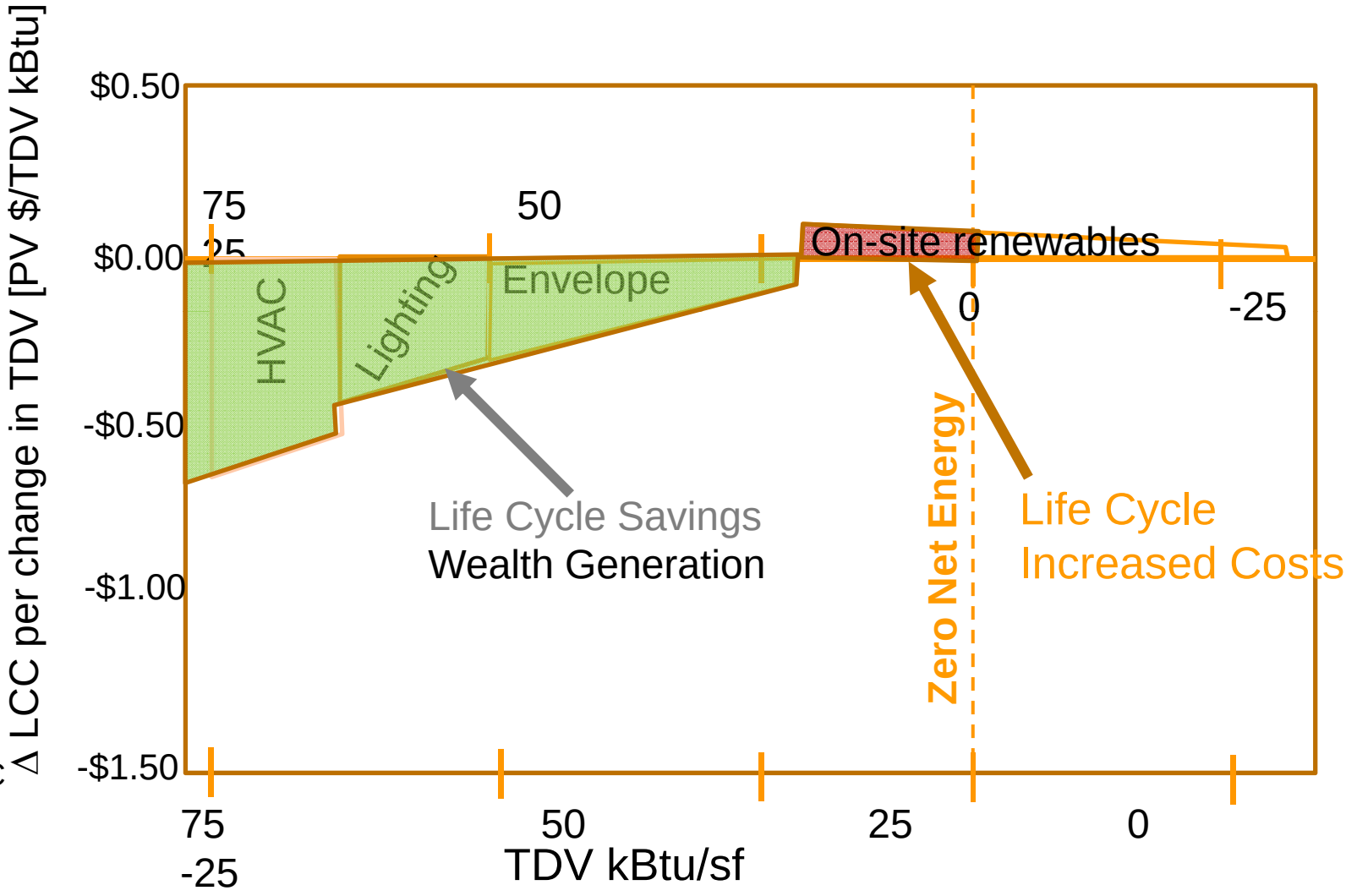
Measures similar to those proposed for 2016 & 2019 codes

ZNE Cost-Effective
B/C Ratio = 18.43/9.25 = 2.0

Total TDV$ Savings:	-$18.43
Incremental First Cost:	$9.25*
Net Life Cycle Cost:	-$9.19*

Incremental Cost = $18,500 for 2,000 sf home

Societal Value (TDV) reduction curve T-24 covered loads



10:1 B/C

If **life cycle savings** are greater than **life cycle increased costs**, the changes are *"cost-effective in their entirety."* Units of shaded areas = PV $/sf

Update the ZNE rating infrastructure (CBECC and HERS2)

- HERS2 rating includes default plug loads
  - Designed to rate existing buildings and advice on EE upgrades
  - Allows the use of PV to displace loads
  - Uses TDV methodology
  - Has ZNE listed on rating of 0
  - Problem that plugs loads are linear function of house sf
  - Model breaks down for large house sizes
- HERS2 model needs updating and validation
- Similar concept was proposed CALGreen Design Rating
  - Planned as add-on calculation to T-24 compliance software – design rating adds default plug loads to T-24 regulated loads
  - Must be developed in 2013 for 2014 implementation.
  - Plug load model should be improved ASAP

Require ratings on existing homes so ZNE is valued

- Energy is invisible
- Energy rating or utility bills published in advance of home sale differentiates ZNE and other efficient homes
- With Zip Code, square footage and bills simple rating possible.
  - If seller does not like simple rating they can buy HERS rating
- Ideally automatic process to upload simple rating once home is placed into a MLS (multiple listing service) database
- Rules about billing confidentiality need to be reviewed
- CAR will oppose if it creates a barrier at time of sale or creates a liability.

Multiple listing service (MLS) in the future

Hayward, CA 94542

For Sale	$499,000
Zestimate®	$510,568
Est. Mortgage	$1,773/mo
HERS rating:	150
Est Utilities:	$350/mo*
Beds:	3
Baths:	2.5
Sqft:	2,872
Lot:	10,454 sq ft / 0.24 acres
Type:	Single Family
Year built:	1982
Parking:	Garage - Attached
Cooling:	Central
Heating:	Forced air
Fireplace:	Yes
On Zillow:	32 days

Photos | Map | Bird's Eye | Street View

ZNE tier in reach codes for early adopting cities

- Help cities meet their GHG goals
- Prepare market for ZNE by having it apply to volunteering cities
- Work out administrative issues on a smaller scale
- Highlight importance to HCD and BSC

HERS and Design Rating Updates

- HERS Proceeding starting at end of 2013, with expected completion in Fall 2014
- Fix known errors in plug load models
  - Short term: adjustment for large homes
  - Long term: fix algorithms for plug loads (need data)
- Consider aligning with National HERS; IECC 2004/2006 = CA HERS 100
  - Easier for builder outreach, EE mortgages etc.
- Results will be used to determine design rating

Discussion Topics

- "No Regrets" approach to ZNE
  - Risk of success;
  - Risk of focus on deep savings? (depth vs volume)
  - Risk of 300 MW/yr of on-site renewables?
  - What other high priorities would we be missing?
- How can state agencies support ZNE goals?
  - See 7,000 kWh to Zero in 8 Years Flat: A Strategy for Net Zero Energy Residential Buildings by 2020
  - http://www.2020zne.org/

The German experience:

Freiburg solar settlement and business park

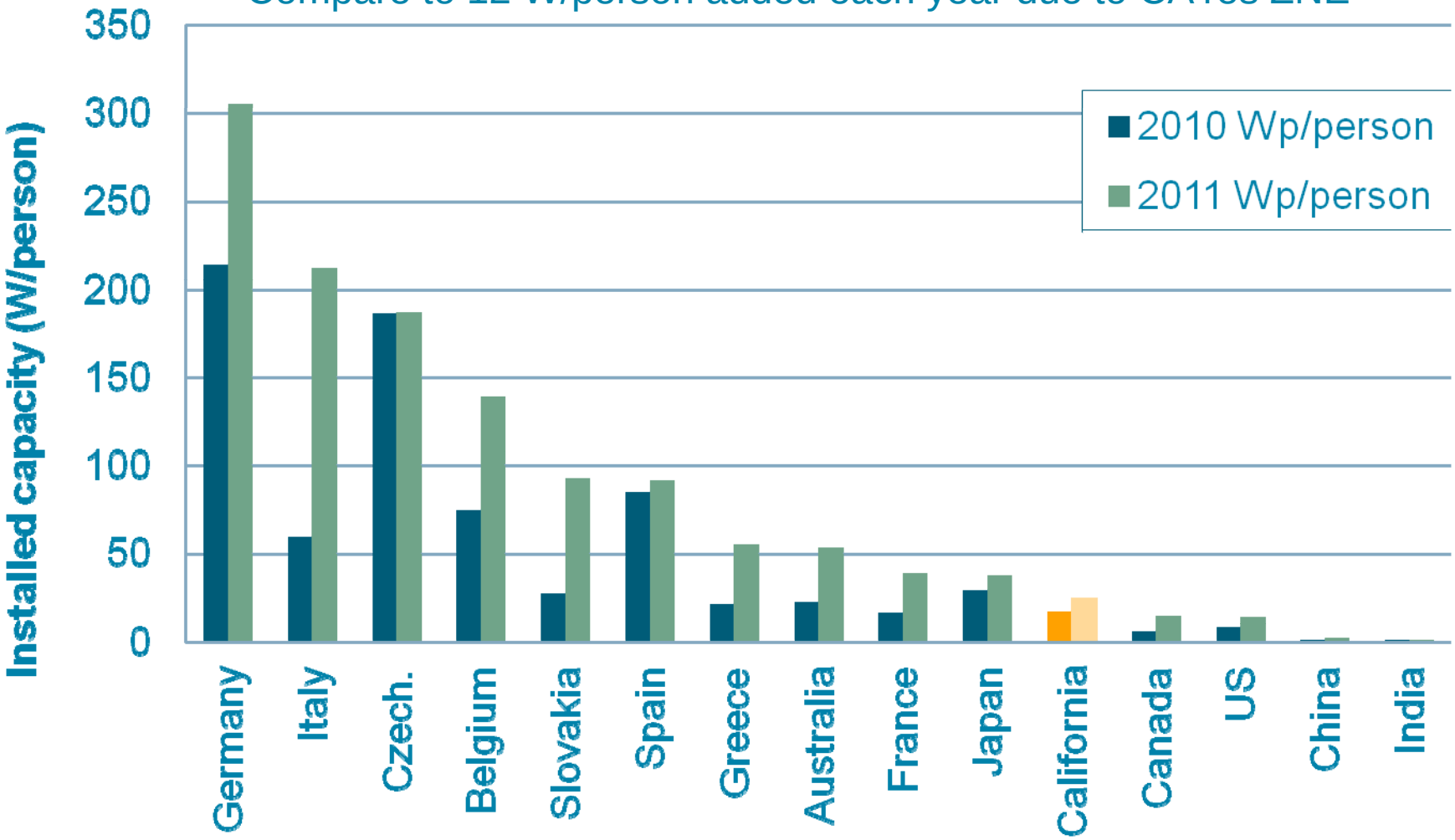
Neighborhood in Hamburg

- **Germany population 81 Million**
- **Germany 25 GW installed PV capacity, 18,000 GWh/yr production**
- **Germany installed cost is approximately 60% of US installed cost**

- **California population 38 Million**
- **CA 1 GW installed capacity, 1,500 GWh/yr production**
- **CA Solar Initiative program added 310 MW over last 12 months**
- **All ZNE homes in 2020 would add approximately 400 MW/yr (12 Watt/person-yr)**

Installed PV capacity Watt (peak) per person

Compare to 12 W/person added each year due to CA res ZNE



http://en.wikipedia.org/wiki/Solar_power_by_country

CA from http://www.californiasolarstatistics.ca.gov/reports/monthly_stats/

For more info

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Appendix

McHugh Energy Consultants

What is on-site renewable energy?

- On-site – first start with CPUC definition:
  - "…single "project" seeking development entitlements and building code permits …"
  - Final implementation avenue (2020 and 2030 goals) though building codes.
  - Allows onsite renewables on carports, common areas, club houses, ground mounted on same development site etc.
- On-site renewable energy (only electricity exported)
  - Photovoltaic
  - Small hydro
  - Solar thermal electricity
  - Wind generated electricity
  - Does **not** include: biomass, landfill gas, fuel cells,
    - *no imports of fuel to serve device and no on-site emissions*

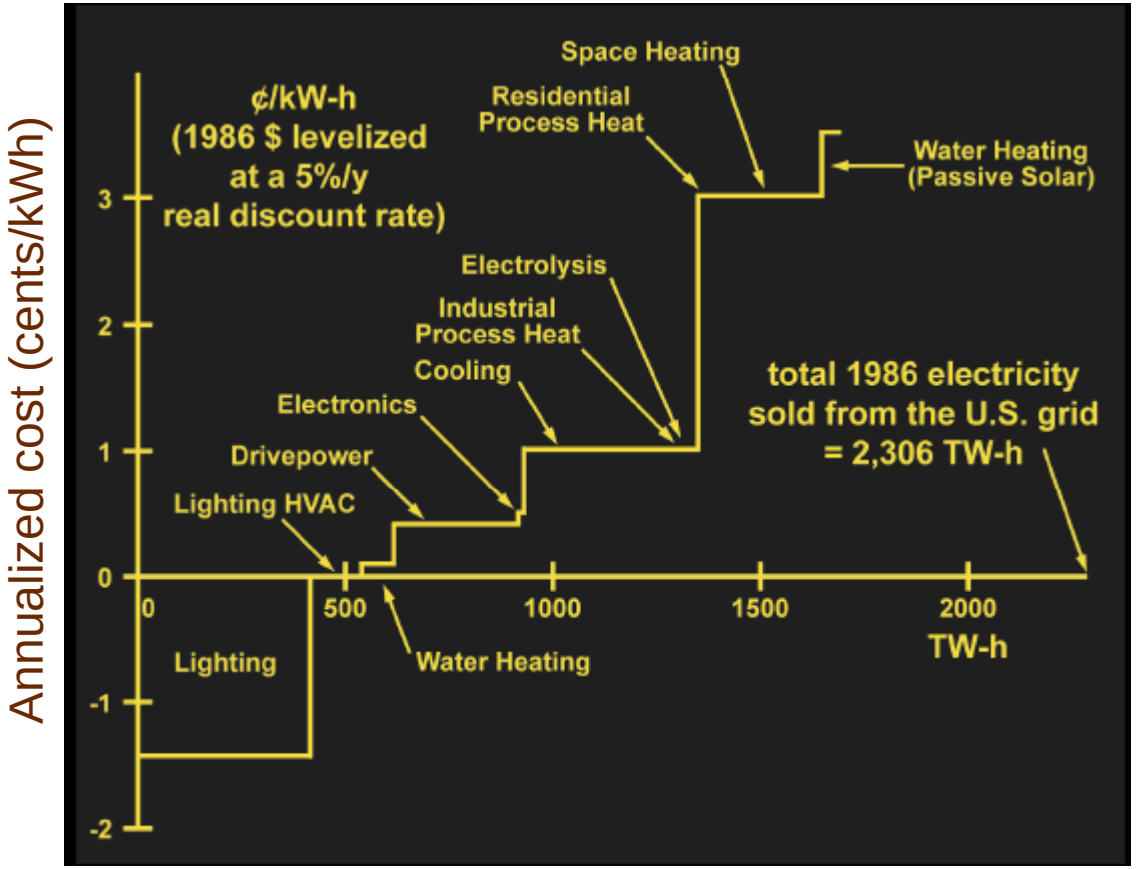
Should ZNE include Embodied Energy and Transportation Energy?

- Transportation energy doubles PV offset
  - Assuming electric vehicles
  - Even more if std combustion vehicle
- Embodied energy in construction materials
  - Embodied energy in homes ~700,000 Btu/sf
  - 2,000 sf house ~1,400 Million Btus.
  - Source energy consumption ~110 Million Btu/yr
  - 13 years of operational energy “in the hole”
  - Could be a burdensome “paper chase”
- Embodied energy in water (typical residence)
  - Northern California - 395 kWh/yr
  - Southern California - 1,270 kWh/yr
- Good considerations after State achieves initial target
  - Opportunity for ZNE equivalent if no solar access

Life Cycle Cost Curve for TDV Reductions

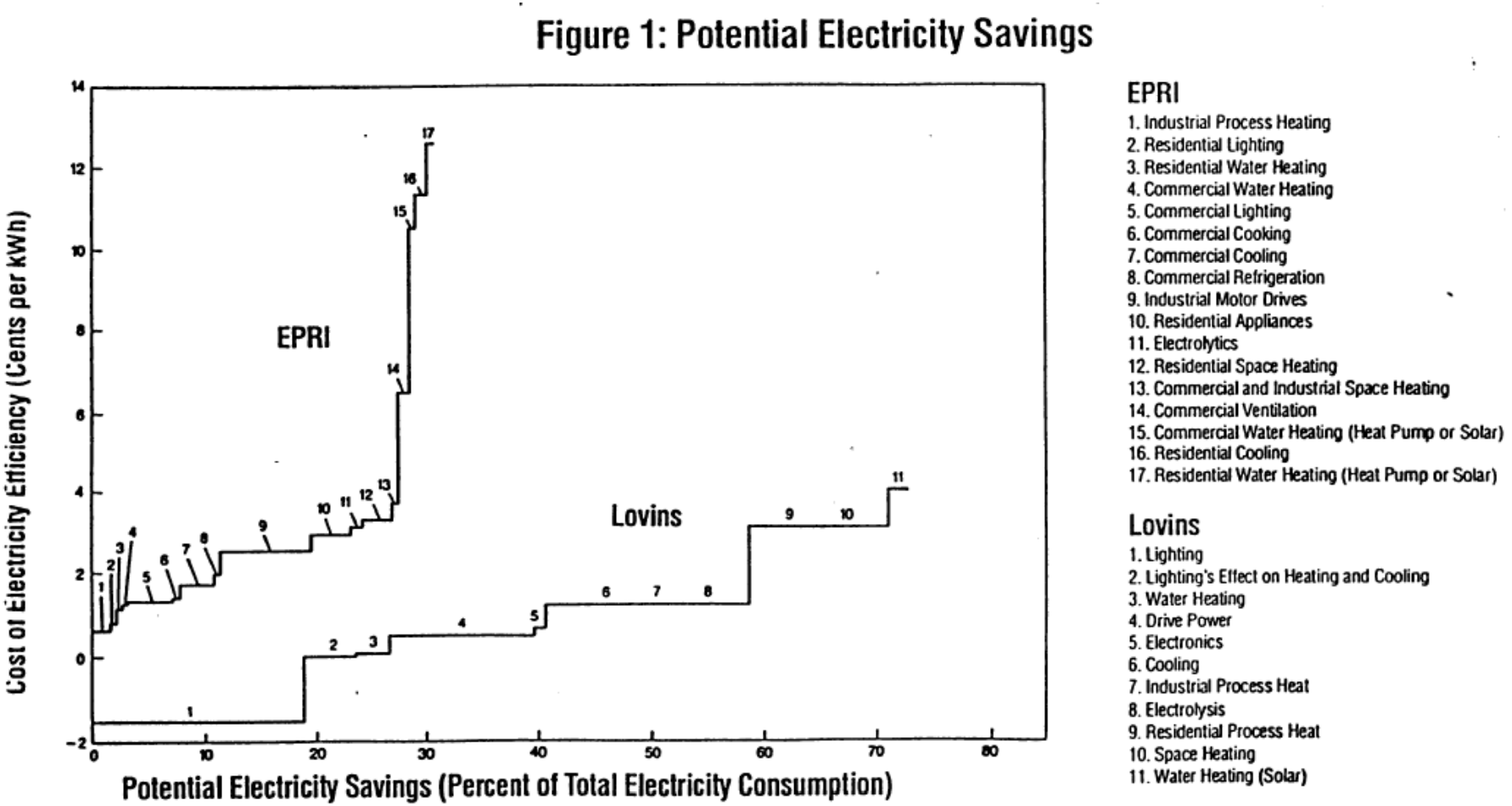
- Similar to efficiency supply cost curve developed by Lovins
- Similar to Carbon abatement curve by McKinsey Company
- Rank measures by their impact on life cycle cost
- Simulate measures in order of their impact on life cycle cost from lowest (largest decrease in LCC) to greatest (largest increase in LCC)
  - Addresses interaction effects

1989 supply curve for saveable US electricity (Lovins)



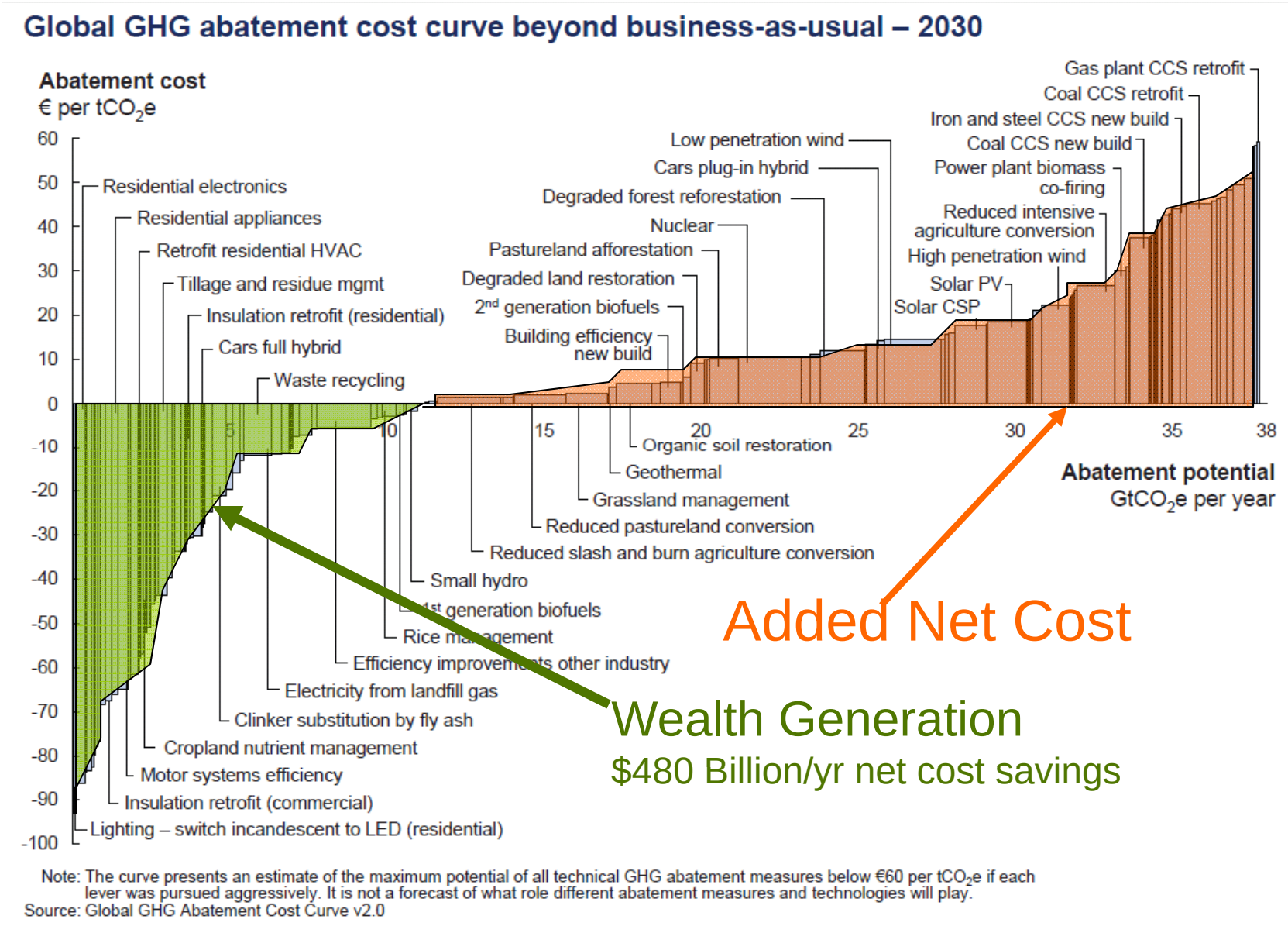
Amory Lovins. "The Future of Energy," Harvard University, 3 December 2008
Profitable Solutions to Climate, Oil, and Proliferation

Efficiency Supply Cost Curve
Lovins vs EPRI



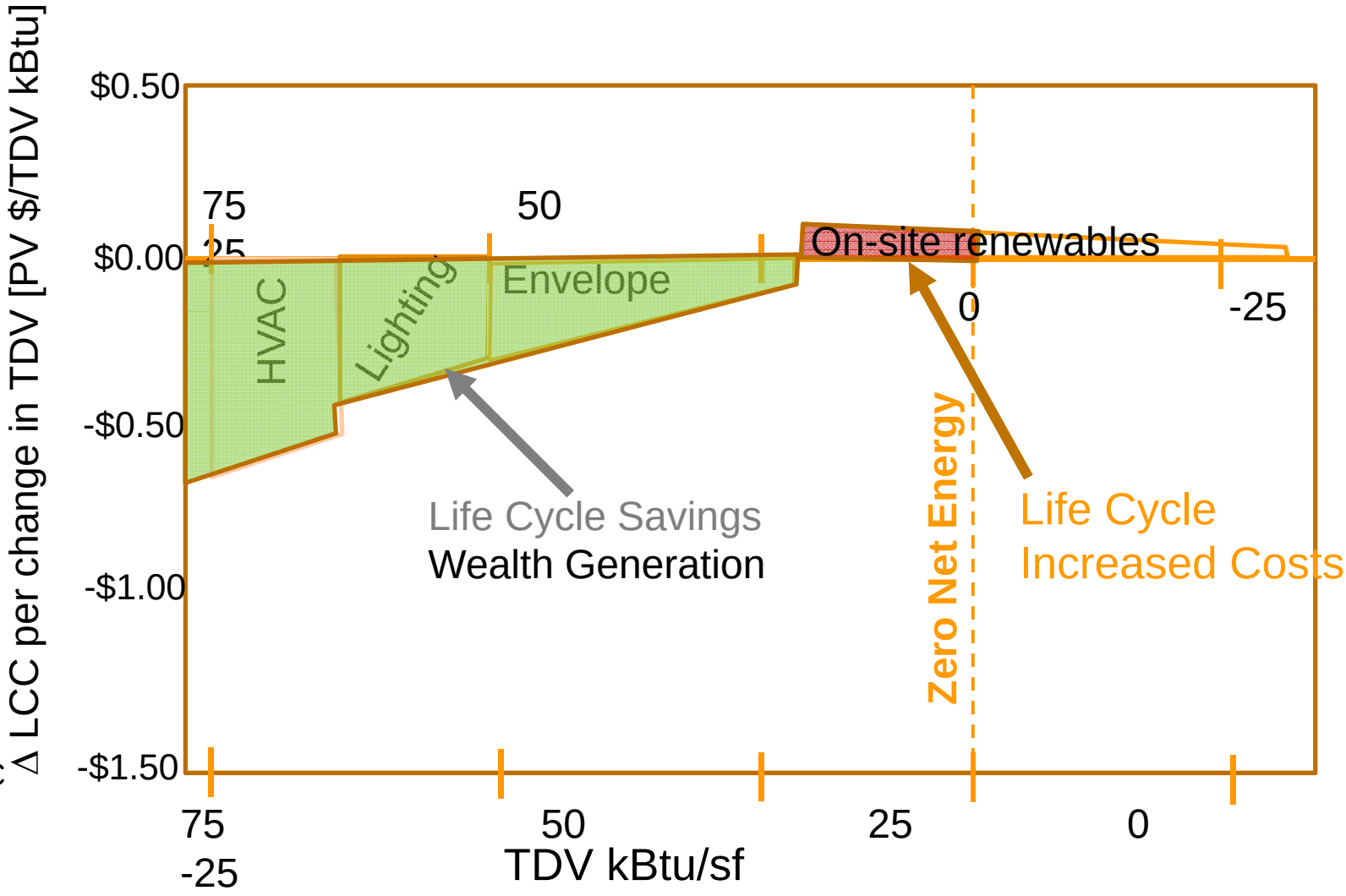
Reproduced from Alfred E. Kahn, "Rational Least-Cost Planning," The Electricity Journal, June 1991, page 14

McKinsey Supply Curve for Carbon Abatement



Note: The curve presents an estimate of the maximum potential of all technical GHG abatement measures below €60 per tCO_2e if each lever was pursued aggressively. It is not a forecast of what role different abatement measures and technologies will play.
Source: Global GHG Abatement Cost Curve v2.0

Societal Value (TDV) reduction curve T-24 covered loads



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Calculating ΔLCC per TDV [PV $/TDV kBtu]

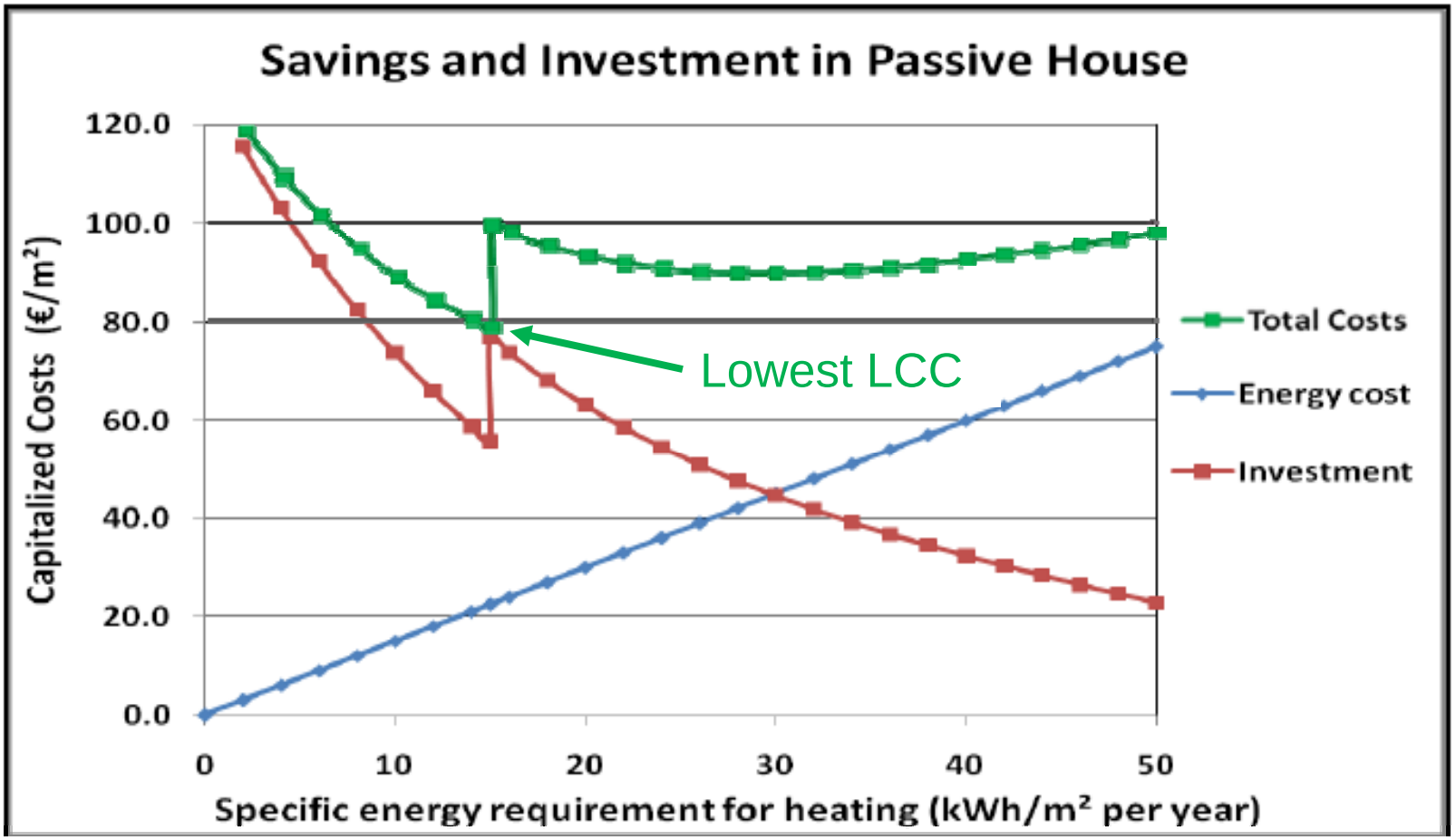
- ΔLCC = Change in Life Cycle Cost

$$\Delta LCC = \begin{bmatrix} \text{Incremental First Cost} \\ + \text{Present Valued Maintenance Cost} \\ - \text{Present Valued Energy Cost Savings} \end{bmatrix}$$

PV energy cost savings = TDV energy savings (TDV kBtu) x TDV Conversion (PV$/kBtu)

- PV Adjustment Factors (2011 $/kBtu)
- Res (30-yr) 0.173188113
- Non-Res (15-yr) 0.088996791
- Non-Res (30-yr) 0.153990148

Passive House cost-effectiveness curve with elimination of heating system



Similar concept for compressorless comfort home

Societal Value of Energy (TDV)

Carbon not only issue for California

- Generation and transmission capacity
- NOx and particulate air pollution

Societal Value (TDV) unified accounting for policy trade-offs.

- Participant cost plus carbon and other externalities
  - Not societal cost test which is TRC+ externalities

Relatively easy to add other policy decisions to Societal Value

- Value of water
- Transportation (locational efficiency)

- Time Dependent Valuation (TDV) – basis of trade-offs in T-24 ACM and Whole House Home Energy Rating (HERS)
- CPUC program evaluation(E3 calculator) based on similar metric
  - E3 costs are avoided costs (including CO_2)
  - Societal (TDV) values equivalent to E3 + retail rate adder

Residential Building Standards

- Zero Net Energy is organizing principle
  - Basis of CPUC policy – EE Strategic Plan
  - Basis of CEC Policy – IEPR
  - Reduce energy consumption though efficiency first
    - *Implement all efficiency that is cheaper than future cost of PV*
  - Serve remaining load with on-site renewables
    - *Remove barriers to PV (cost is 35% cheaper in Germany)*
    - *Differentiate PV by durability, annual performance and long term performance*

- Goals by Code Cycle
  - "All new residential construction in California will be zero net energy by 2020" CPUC Energy Efficiency Strategic Plan.
    - *2019: Title 24 requires renewables and ZNE in all new homes*
    - *2016: prepare market by including renewable requirement in ACM.*
    - *2013: opportunity to place solar thermal and PV into ACM*

Residential Reach Codes

- Local ordinances (reach codes) prepare the market in advance of statewide standards.
- CALGreen voluntary tiers intended for local government adoption
  - *Tier 1 is one code cycle in advance of Title 24, Part 6*
    - 2016 CALGreen Tier 1 should be ZNE
  - *Tier 2 is two cycles in advance of Title 24, Part 6*
    - 2013 CALGreen Tier 2 should be ZNE
- Diversity of approaches depending on local market requirements and conditions
  - *Opportunity to learn from leading cities which approach works well for different market sectors and geographic regions*

What things should have happened in 2013 code cycle?

- Start allowing PV trade-offs (max kBtu cap, window area trade-off etc)
- Join other states (WA, OR) that are using dual path in lieu of preemption waiver
- Reach Codes (CALGreen) get market ready for future:
  - Residential Tier 2 is ZNE,
  - Residential Tier 1 best estimate of 2016 Title 24
- 1 out of 3 is better than nothing

Which tools must calculate ZNE?

- What trade-offs are allowed with on-site renewables?
- Performance software
  - CBECC design rating
- HERS II rating
- Billing analysis (interval meters)