

# Net Emissions Analysis Tool (NEAT) Working Group

*Formally the Residential Commercial Appliance Life  
Cycle Analysis Working Group*

Meeting #2  
Nov 16, 2017

Scott A. Epstein Ph.D.

Marc Carreras-Sospedra Ph.D.



South Coast  
Air Quality Management District

# Outline

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1. Project Objectives
2. The role of the NEAT workgroup
3. Development progress
4. Overview of “Demand” segment of the Residential NEAT
5. Overview of the Residential solar PV calculator module
6. Topics for open discussion
7. Public comments



# Project Objectives

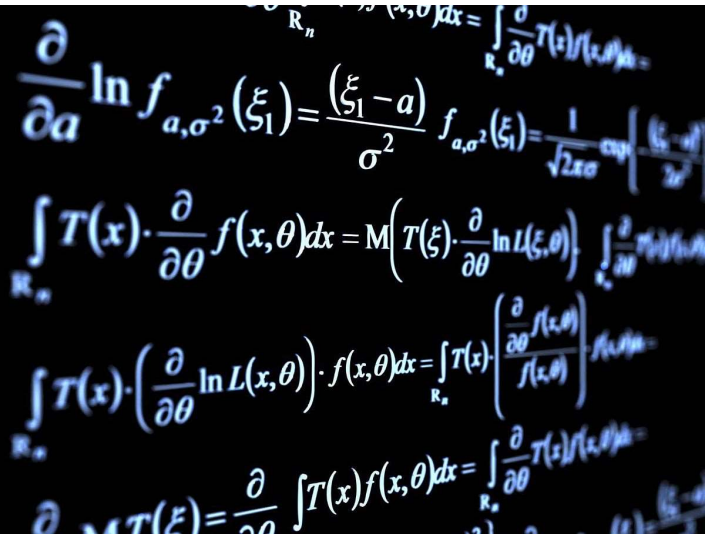
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- Develop an analytical software tool that will help to evaluate the most cost-effective strategies for NO<sub>x</sub> and GHG emission reductions from the commercial and residential sector.
- The ideal characteristics of the tool:
  - Comprehensive, yet user-friendly for general-public
  - Level of complexity determined by the user
  - Intuitive workflow with extensive documentation embedded into the software



# The Role of the NEAT Workgroup

- Bring to light applicable data from peer-reviewed or government studies
- Ensure that assumptions and methodologies are scientifically valid and appropriate
- Help maximize tool usability
- *Policy discussions are most appropriate after the model development phase*



The image shows a chalkboard with several mathematical equations written in white chalk. The equations are related to probability distributions and calculus. The most prominent equation is the derivative of the natural logarithm of a normal distribution's probability density function with respect to its mean parameter  $\mu$ . Other equations include the integral of the product of a function and the derivative of the log-likelihood function, and the derivative of the integral of a function with respect to a parameter.

$$\frac{\partial}{\partial \mu} \ln f_{a, \sigma^2}(\xi_1) = \frac{(\xi_1 - a)}{\sigma^2} f_{a, \sigma^2}(\xi_1) = \frac{1}{\sqrt{2\pi\sigma}} \exp\left\{-\frac{(\xi_1 - a)^2}{2\sigma^2}\right\}$$
$$\int_{R_n} T(x) \cdot \frac{\partial}{\partial \theta} f(x, \theta) dx = M\left(T(\xi) \cdot \frac{\partial}{\partial \theta} \ln L(\xi, \theta)\right)$$
$$\int_{R_n} T(x) \cdot \left(\frac{\partial}{\partial \theta} \ln L(x, \theta)\right) \cdot f(x, \theta) dx = \int_{R_n} T(x) \cdot \left(\frac{\partial}{\partial \theta} \frac{f(x, \theta)}{f(x, \theta)}\right) \cdot f(x, \theta) dx$$
$$\frac{\partial}{\partial \theta} \int_{R_n} T(x) f(x, \theta) dx = \int_{R_n} T(x) \frac{\partial}{\partial \theta} f(x, \theta) dx$$



# Development Progress

Residential NEAT	Not Yet Started	In Progress	Draft Complete
Building of tool framework (GUI, file I/O)			X
Collection of input data			X
Demand segment of tool			X
Implementation of distributed solar			X
Implementation of distributed battery storage			X
Electric Rate Calculator			X
Natural Gas Rate Calculator		X	
Implementation of net metering	X		
Solar and battery cost calculator			X
Electric generation emission factors		X	
Gas leak and electricity transportation loss	X		



# Topics for Today's Meeting

Residential NEAT	Not Yet Started	In Progress	Draft Complete
<b>Building of tool framework (GUI, file I/O)</b>			<b>X</b>
<b>Collection of input data</b>			<b>X</b>
<b>Demand segment of tool</b>			<b>X</b>
<b>Implementation of distributed solar</b>			<b>X</b>
Implementation of distributed battery storage			X
Electric Rate Calculator			X
Natural Gas Rate Calculator		X	
Implementation of net metering	X		
Solar and battery cost calculator			X
Electric generation emission factors		X	
Gas leak and electricity transportation loss	X		



# Demand Module Design

Residential Net Emissions Analysis Tool version 1.0 beta

Demand
  Intermediate Results
  Power Supply
  Economics
  placeholder1
  placeholder2
  Results

Housing Category:
  Single-Family
  Multi-Family
  Mobile Home
  Aggregate

Climate Zone:
  6 Coastal
  8 S. Near-Coastal
  9 N. Near-Coastal
  10 S. Inland
  15 S. Desert
  16 Mountain
  All
 [CZ MAP](#)

Populate Values:

**BASELINE TECHNOLOGY MIX PARAMETERS** [Show Column Information](#)

Fuel	Technology	UEC	NOX EF	CO2e EF	Unit Cost	Install Cost	Lifetime	Penetration
Electric	Water Heat	2468	0	0	368	1700	13	0.0740
Electric	Solar Water Heat with Electric Backup	1964	0	0	1411	3869	13	0
NatGas	Conventional Water Heater	193	0.0023	11.7600	653	1900	13	0.7160
NatGas	Solar Water Heat with Gas Backup	163	0.0023	11.7600	4349	3869	13	0

Table values can be edited manually. Tools to implement common editing scenarios are provided:

**Replace Technology Tool**

Select technology to phase-out:

Select technology to use instead:

**Adopt More Efficient Technology**

Select technology to improve efficiency:

% of households with technology in the future that will adopt more efficient version:


Use FUTURE MORE EFFICIENT TECHNOLOGY table to specify parameters of more efficient tech.

**FUTURE TECHNOLOGY MIX**

Fuel	Technology	Penetration
Electric	Water Heat	0.0740
Electric	Solar Water Heat with Electric Backup	0
NatGas	Conventional Water Heater	0.7160
NatGas	Solar Water Heat with Gas Backup	0

**FUTURE MORE EFFICIENT TECHNOLOGY**

Fuel	Technology	% adoption	UEC	NOX EF	CO2e EF	Unit Cost	Install Cost	Lifetime
Electric	Water Heat	0	2468	0	0	368	1700	13
Electric	Solar Water Heat with Electric Backup	0	1964	0	0	1411	3869	13
NatGas	Conventional Water Heater	0	193	0.0023	11.7600	653	1900	13
NatGas	Solar Water Heat with Gas Backup	0	163	0.0023	11.7600	4349	3869	13




# Demand Module Design

Residential Net Emissions Analysis Tool version 1.0 beta

Demand Intermediate Results Power Supply Economics placeholder1 placeholder2 Results

Housing Category  
 Single-Family  Multi-Family  Mobile Home  Aggregate

Climate Zone  
 6 Coastal  8 S. Near-Coastal  9 N. Near-Coastal  11 S. Inland  15 S. Desert  16 Mountain  All CZ MAP

Populate Values  
 Load Default Parameters    
 Load Saved Parameters

Hot water heating Kitchen Laundry Miscellaneous Pool Space heating and cooling Transportation

**BASELINE TECHNOLOGY MIX PARAMETERS** [Show Column Information](#)

Fuel	Technology	UEC	NOX EF	CO2e EF	Unit Cost	Install Cost	Lifetime	Penetration
Electric	Water Heat	2468	0	0	368	1700	13	0.0740
Electric	Solar Water Heat with Electric Backup	1964	0	0	1411	3869	13	0
NatGas	Conventional Water Heater	193	0.0023	11.7600	653	1900	13	0.7160
NatGas	Solar Water Heat with Gas Backup	163	0.0023	11.7600	4349	3869	13	0

Table values can be edited manually. Tools to implement common editing scenarios are provided:

**Replace Technology Tool**  
 Select technology to phase-out:   
 Select technology to use instead:

**Adopt More Efficient Technology**  
 Select technology to improve efficiency:   
 % of households with technology in the future that will adopt more efficient version:   
 Use FUTURE MORE EFFICIENT TECHNOLOGY table to specify parameters of more efficient tech.

**FUTURE TECHNOLOGY MIX**

Fuel	Technology	Penetration
Electric	Water Heat	0.0740
Electric	Solar Water Heat with Electric Backup	0
NatGas	Conventional Water Heater	0.7160
NatGas	Solar Water Heat with Gas Backup	0

**FUTURE MORE EFFICIENT TECHNOLOGY**

Fuel	Technology	Penetration	% adoption	UEC	NOX EF	CO2e EF	Unit Cost	Install Cost	Lifetime
Electric	Water Heat	0.0740	0	2468	0	0	368	1700	13
Electric	Solar Water Heat with Electric Backup	0	0	1964	0	0	1411	3869	13
NatGas	Conventional Water Heater	0.7160	0	193	0.0023	11.7600	653	1900	13
NatGas	Solar Water Heat with Gas Backup	0	0	163	0.0023	11.7600	4349	3869	13

Save Parameters to File





# Demand Module Design

Residential Net Emissions Analysis Tool version 1.0 beta

**Selection of climate zone automatically modifies default input parameters below**

Climate Zone

6 Coastal  8 S. Near-Coastal  9 N. Near-Coastal  10 S. Inland  15 S. Desert  16 Mountain  All [CZ MAP](#)

Hot water heating Kitchen Laundry Miscellaneous Pool Space heating and cooling Transportation

**BASELINE TECHNOLOGY MIX PARAMETERS**

Fuel	Technology	UEC	NOX EF	CO2e EF	Unit Cost	Install Cost	Lifetime	Penetration
Electric	Water Heat	2468	0	0	368	1700	13	0.0740

Table values cannot be edited manually. Tools to implement common editing scenarios are provided:

Replace Technology Tool

Best technology to phase-out: Electric Water Heat

Select technology to use instead: Electric Solar Water Heat with Electric Backup

Implement

Adopt More Efficient Technology

Select technology to improve efficiency: Electric Water Heat

% of households with technology in the future that will adopt more efficient version: 0

Use FUTURE MORE EFFICIENT TECHNOLOGY table to specify parameters of more efficient tech.

Implement

Save Parameters to File [ADVANCE TO NEXT](#)



# Demand Module Design

Residential Net Emissions Analysis Tool version 1.0 beta

Demand Intermediate Results Power Supply Economics placeholder1 placeholder2 Results

Housing Category:  Single-Family  Multi-Family  Mobile Home  Aggregate

Climate Zone:  6 Coastal  8 S. Near-Coastal  9 N. Near-Coastal  10 S. Inland  15 S. Desert  16 Mountain  All [CZ MAP](#)

Populate Values: Load Default Parameters (green dot) Load Saved Parameters (black dot)

Hot water heating Kitchen Laundry Miscellaneous Pool Space heating and cooling Transportation


**BASELINE TECHNOLOGY MIX PARAMETERS** [Show Column Information](#) Table values can be edited manually. Tools to implement common editing scenarios are provided:

Number of Households							
	CZ 6	CZ 8	CZ 9	CZ 10	CZ 15	CZ 16	All
Single Family	409,449	765,227	992,911	694,024	11,775	94,789	<b>2,968,175</b>
Multi Family	502,320	665,452	1,003,905	231,663	1,809	22,538	<b>2,427,687</b>
Mobile Home	18,475	31,758	26,564	66,867	2,763	4,783	<b>151,210</b>
<b>Aggregate</b>	<b>930,244</b>	<b>1,462,437</b>	<b>2,023,380</b>	<b>992,554</b>	<b>16,347</b>	<b>122,110</b>	<b>5,547,072</b>

FUTURE

Data calculated from 2015 US Census estimates and climate zone geography.

Save Parameters to File **ADVANCE TO NEXT**




# Demand Module Design

Residential Net Emissions Analysis Tool version 1.0 beta

Demand | Intermediate Results | Power Supply | Economics | placeholder1 | placeholder2 | Results

Housing Category:  Single-Family  Multi-Family  Mobile Home  Aggregate

Climate Zone:  6 Coastal  8 S. Near-Coastal  9 N. Near-Coastal  10 S. Inland  15 S. Desert  16 Mountain  All [CZ MAP](#)

Populate Values

Hot water heating | **Kitchen** | Laundry | Miscellaneous | Pool | Space heating and cooling | Transportation

**BASELINE TECHNOLOGY MIX PARAMETERS** [Show Column Information](#)

Fuel	Technology	UEC	NOX EF	CO2e EF	Unit Cost	Install Cost	Lifetime	Penetration
Electric	Water Heat	2468	0	0	368	1700	13	0.0740
Electric	Solar Water Heat with Electric Backup	1964	0	0	1411	3869	13	0
NatGas	Conventional Water Heater	193	0.0023	11.7600	653	1900	13	0.7160
NatGas	Solar Water Heat with Gas Backup	163	0.0023	11.7600	4349	3869	13	0

Table values can be edited manually. Tools to implement common editing scenarios are provided:

**Replace Technology Tool**

Select technology to phase-out:

Select technology to use instead:

**Adopt More Efficient Technology**

Select technology to improve efficiency:

% of households with technology in the future that will adopt more efficient version:

Use FUTURE MORE EFFICIENT TECHNOLOGY table to specify parameters of more efficient tech.

**FUTURE TECHNOLOGY MIX**

Fuel	Technology	Penetration
Electric	Water Heat	0.0740
Electric	Solar Water Heat with Electric Backup	0
NatGas	Conventional Water Heater	0.7160
NatGas	Solar Water Heat with Gas Backup	0

**FUTURE MORE EFFICIENT TECHNOLOGY**

Fuel	Technology	Penetration	% adoption	UEC	NOX EF	CO2e EF	Unit Cost	Install Cost	Lifetime
Electric	Water Heat	0.0740	0	2468	0	0	368	1700	13
Electric	Solar Water Heat with Electric Backup	0	0	1964	0	0	1411	3869	13
NatGas	Conventional Water Heater	0.7160	0	193	0.0023	11.7600	653	1900	13
NatGas	Solar Water Heat with Gas Backup	0	0	163	0.0023	11.7600	4349	3869	13

Can load default input parameters or load previously saved values (.csv format)



# Demand Module Input Parameters

	Definition	Units	Source
UEC	Units of energy consumption	kWh/year for electric therms/year for NG gal/year for gasoline, diesel	CEC RASS 2009 for appliances EMFAC 2014 analysis for vehicles
NOX EF	Point of Use NOx emission factor	lb/therm for NG lb/gal for gasoline, diesel	AQMD Rule 1121, 1111, 1147 AP-42 from EPA, CEC funded LBNL study, BAAQMD methodology
CO2e EF	Point of Use CO2e emission factor	lb/therm for NG lb/gal for gasoline, diesel	AP-42 from EPA



# Demand Module Input Parameters

	Definition	Units	Source
Unit Cost	Cost to purchase appliance	\$	Appliances: Consumer Reports, Amazon, Sears, Home Depot, 4—350 quotes per appliance Vehicles: weighted average calculated with fuel economy.gov, insideevs.com, hybridcars.com, goodcarbadcar.net
Install Cost	Cost to install appliance	\$	Appliances: Homeadvisor.com, home.costhelper.com, homewyse.com
Lifetime	Appliance lifetime	years	Appliances: epa.gov, nachi.org Vehicles: CARB EMFAC survival rates
Penetration	Fraction of households with specific technology	unitless	Appliances: CEC RAAS 2009 Vehicles: CARB EMFAC



# Demand Module Input Parameters

	Definition	Units	Source
Unit Cost	Cost to purchase appliance	\$	Appliances: Consumer Reports, Amazon, Sears, Home Depot, 4—350 quotes per appliance Vehicles: weighted average calculated with fuel economy.gov, insideevs.com, hybridcars.com, goodcarbadcar.net
Install Cost	Cost to install appliance	\$	Appliances: Homeadvisor.com, home.costhelper.com, homewyse.com
Lifetime	Appliance lifetime	years	Appliances: epa.gov, nachi.org Vehicles: CARB EMFAC survival rates
Penetration	Fraction of households with specific technology	unitless	Appliances: CEC RAAS 2009 Vehicles: CARB EMFAC
% Adoption	Fraction of households with new/more efficient technology	unitless	Defined by user based on scenario



# Hot water heating

Residential Net Emissions Analysis Tool version 1.0 beta

Demand Intermediate Results Power Supply Economics placeholder1 placeholder2 Results

Housing Category:  Single-Family  Multi-Family  Mobile Home  Aggregate

Climate Zone:  6 Coastal  8 S. Near-Coastal  9 N. Near-Coastal  10 S. Inland  15 S. Desert  16 Mountain  All [CZ MAP](#)

Populate Values:

Hot water heating Kitchen Laundry Miscellaneous Pool Space heating and cooling Transportation

**BASELINE TECHNOLOGY MIX PARAMETERS** [Show Column Information](#)

Fuel	Technology	UEC	NOX EF	CO2e EF	Unit Cost	Install Cost	Lifetime	Penetration
Electric	Water Heat	2468	0	0	368	1700	13	0.0740
Electric	Solar Water Heat with Electric Backup	1964	0	0	1411	3869	13	0
NatGas	Conventional Water Heater	193	0.0023	11.7600	653	1900	13	0.7160
NatGas	Solar Water Heat with Gas Backup	163	0.0023	11.7600	4349	3869	13	0

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Select technology to use instead:

Adopt More Efficient Technology

Select technology to use instead:

% of households with technology in the future that will adopt more efficient version:

Use FUTURE MORE EFFICIENT TECHNOLOGY table to specify parameters of more efficient tech.

**FUTURE TECHNOLOGY MIX**

Fuel	Technology	Penetration
Electric	Water Heat	0.0740
Electric	Solar Water Heat with Electric Backup	0
NatGas	Conventional Water Heater	0.7160
NatGas	Solar Water Heat with Gas Backup	0

**FUTURE MORE EFFICIENT TECHNOLOGY**

Fuel	Technology	% adoption	UEC	NOX EF	CO2e EF	Unit Cost	Install Cost	Lifetime
Electric	Water Heat	0	2468	0	0	368	1700	13
Electric	Solar Water Heat with Electric Backup	0	1964	0	0	1411	3869	13
NatGas	Conventional Water Heater	0	193	0.0023	11.7600	653	1900	13
NatGas	Solar Water Heat with Gas Backup	0	163	0.0023	11.7600	4349	3869	13



# Kitchen

Residential Net Emissions Analysis Tool version 1.0 beta

Demand Intermediate Results Power Supply Economics placeholder1 placeholder2 Results

Housing Category:  Single-Family  Multi-Family  Mobile Home  Aggregate

Climate Zone:  6 Coastal  8 S. Near-Coastal  9 N. Near-Coastal  10 S. Inland  15 S. Desert  16 Mountain  All [CZ MAP](#)

Populate Values:

Hot water heating Kitchen Laundry Miscellaneous Pool Space heating and cooling Transportation

**BASELINE TECHNOLOGY MIX PARAMETERS** [Show Column Information](#)

Fuel	Technology	UEC	NOX EF	CO2e EF	Unit Cost	Install Cost	Lifetime	Penetration
Electric	Range Oven Combination	253	0	0	1000	140	18	0.4560
Electric	Dishwasher	69	0	0	800	344	12	0.6650
Electric	First Refrigerator	755	0	0	1999	108	17.5000	1
Electric	Second Refrigerator	1003	0	0	1999	108	17.5000	0.2140
Electric	Freezer	882	0	0	630	108	20	0.1650
Electric	Microwave	119	0	0	180	158	12	0.9190
NatGas	Range Oven Combination	33	0.0092	11.7600	1890	150	18	0.6270

Table values can be edited manually. Tools to implement common editing scenarios are provided:

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Select technology to phase-out:

Select technology to use instead:

**Adopt More Efficient Technology**

Select technology to improve efficiency:

% of households with technology in the future that will adopt more efficient version:

Use FUTURE MORE EFFICIENT TECHNOLOGY table to specify parameters of more efficient tech.

[ADVANCE TO NEXT](#)

**FUTURE TECHNOLOGY MIX**

Fuel	Technology	Penetration
Electric	Range Oven Combination	0.4560
Electric	Dishwasher	0.6650
Electric	First Refrigerator	1
Electric	Second Refrigerator	0.2140
Electric	Freezer	0.1650
Electric	Microwave	0.9190
NatGas	Range Oven Combination	0.6270

**FUTURE MORE EFFICIENT TECHNOLOGY**

Fuel	Technology	Penetration	% adoption	UEC	NOX EF	CO2e EF	Unit Cost	Install Cost	Lifetime
Electric	Range Oven Combination	0.4560	0	253	0	0	1000	140	18
Electric	Dishwasher	0.6650	0	69	0	0	800	344	12
Electric	First Refrigerator	1	0	755	0	0	1999	108	17.5000
Electric	Second Refrigerator	0.2140	0	1003	0	0	1999	108	17.5000
Electric	Freezer	0.1650	0	882	0	0	630	108	20
Electric	Microwave	0.9190	0	119	0	0	180	158	12
NatGas	Range Oven Combination	0.6270	0	33	0.0092	11.7600	1890	150	18





# Laundry

Residential Net Emissions Analysis Tool version 1.0 beta

Demand | Intermediate Results | Power Supply | Economics | placeholder1 | placeholder2 | Results

Housing Category:  Single-Family  Multi-Family  Mobile Home  Aggregate

Climate Zone:  6 Coastal  8 S. Near-Coastal  9 N. Near-Coastal  10 S. Inland  15 S. Desert  16 Mountain  All [CZ MAP](#)

Populate Values:

Hot water heating | Kitchen | Laundry | Miscellaneous | Pool | Space heating and cooling | Transportation

**BASELINE TECHNOLOGY MIX PARAMETERS** [Show Column Information](#)

Fuel	Technology	UEC	NOX EF	CO2e EF	Unit Cost	Install Cost	Lifetime	Penetration
Electric	Dryer	615	0	0	750	219	18	0.2890
Electric	Clothes Washer	82	0	0	850	100	13	0.7320
NatGas	Dryer	25	0.0136	11.7600	800	100	18	0.3830

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Select technology to phase-out:

Select technology to use instead:

**Adopt More Efficient Technology**

Select technology to improve efficiency:

% of households with technology in the future that will adopt more efficient version:

Use FUTURE MORE EFFICIENT TECHNOLOGY table to specify parameters of more efficient tech.

**FUTURE TECHNOLOGY MIX**

Fuel	Technology	Penetration
Electric	Dryer	0.2890
Electric	Clothes Washer	0.7320
NatGas	Dryer	0.3830

**FUTURE MORE EFFICIENT TECHNOLOGY**

Fuel	Technology	% adoption	UEC	NOX EF	CO2e EF	Unit Cost	Install Cost	Lifetime
Electric	Dryer	0	615	0	0	750	219	18
Electric	Clothes Washer	0	82	0	0	850	100	13
NatGas	Dryer	0	25	0.0136	11.7600	800	100	18



# Miscellaneous

Residential Net Emissions Analysis Tool version 1.0 beta

Demand | Intermediate Results | Power Supply | Economics | placeholder1 | placeholder2 | Results

Housing Category:  Single-Family  Multi-Family  Mobile Home  Aggregate

Climate Zone:  6 Coastal  8 S. Near-Coastal  9 N. Near-Coastal  10 S. Inland  15 S. Desert  16 Mountain  All [CZ MAP](#)

Populate Values:

Hot water heating | Kitchen | Laundry | **Miscellaneous** | Pool | Space heating and cooling | Transportation

**BASELINE TECHNOLOGY MIX PARAMETERS** [Show Column Information](#)

Fuel	Technology	UEC	NOX EF	CO2e EF	Unit Cost	Install Cost	Lifetime	Penetration
Electric	TV	681	0	0	300	288	15	1
Electric	Outdoor Lighting	298	0	0	37	194	40	0.5980
Electric	Home Office	78	0	0	353	397	10.5000	0.1990
Electric	PC	588	0	0	329	397	10.5000	0.8410
Electric	Well Pump	559	0	0	185	1167	15	0.0430
Electric	Other	1734	0	0	0	0	0	1
NatGas	Other	26	0.0136	11.7600	0	0	0	0.0930

Table values can be edited manually. Tools to implement common editing scenarios are provided:

**Replace Technology Tool**

Select technology to phase-out:

Select technology to use instead:

**Adopt More Efficient Technology**

Select technology to improve efficiency:

% of households with technology in the future that will adopt more efficient version:

Use FUTURE MORE EFFICIENT TECHNOLOGY table to specify parameters of more efficient tech.

**FUTURE TECHNOLOGY MIX**

Fuel	Technology	Penetration
Electric	TV	1
Electric	Outdoor Lighting	0.5980
Electric	Home Office	0.1990
Electric	PC	0.8410
Electric	Well Pump	0.0430
Electric	Other	1
NatGas	Other	0.0930

**FUTURE MORE EFFICIENT TECHNOLOGY**

Fuel	Technology	% adoption	UEC	NOX EF	CO2e EF	Unit Cost	Install Cost	Lifetime
Electric	TV	0	681	0	0	300	288	15
Electric	Outdoor Lighting	0	298	0	0	37	194	40
Electric	Home Office	0	78	0	0	353	397	10.5000
Electric	PC	0	588	0	0	329	397	10.5000
Electric	Well Pump	0	559	0	0	185	1167	15
Electric	Other	0	1734	0	0	0	0	0
NatGas	Other	0	26	0.0136	11.7600	0	0	0



# Pool

Residential Net Emissions Analysis Tool version 1.0 beta

Demand Intermediate Results Power Supply Economics placeholder1 placeholder2 Results

Housing Category:  Single-Family  Multi-Family  Mobile Home  Aggregate

Climate Zone:  6 Coastal  8 S. Near-Coastal  9 N. Near-Coastal  10 S. Inland  15 S. Desert  16 Mountain  All [CZ MAP](#)

Populate Values:

Hot water heating Kitchen Laundry Miscellaneous **Pool** Space heating and cooling Transportation

**BASELINE TECHNOLOGY MIX PARAMETERS** [Show Column Information](#)

Fuel	Technology	UEC	NOX EF	CO2e EF	Unit Cost	Install Cost	Lifetime	Penetration
Electric	Spa Heat	903	0	0	520	750	13	0.0400
Electric	Pool Pump	3502	0	0	230	188	10	0.0860
Electric	Spa	223	0	0	3960	8912	12.5000	0.0770
NatGas	Spa Heat	52	0.0023	11.7600	2048	1000	13	0.0400
NatGas	Pool Heat	151	0.0023	11.7600	2048	1000	13	0.0380

Table values can be edited manually. Tools to implement common editing scenarios are provided:

**Replace Technology Tool**

Select technology to phase-out:

Select technology to use instead:

**Adopt More Efficient Technology**

Select technology to improve efficiency:

% of households with technology in the future that will adopt more efficient version:

Use FUTURE MORE EFFICIENT TECHNOLOGY table to specify parameters of more efficient tech.

**ADVANCE TO NEXT**

**FUTURE TECHNOLOGY MIX**

Fuel	Technology	Penetration
Electric	Spa Heat	0.0400
Electric	Pool Pump	0.0860
Electric	Spa	0.0770
NatGas	Spa Heat	0.0400
NatGas	Pool Heat	0.0380

**FUTURE MORE EFFICIENT TECHNOLOGY**

Fuel	Technology	Penetration	% adoption	UEC	NOX EF	CO2e EF	Unit Cost	Install Cost	Lifetime
Electric	Spa Heat	0.0400	0	903	0	0	520	750	13
Electric	Pool Pump	0.0860	0	3502	0	0	230	188	10
Electric	Spa	0.0770	0	223	0	0	3960	8912	12.5000
NatGas	Spa Heat	0.0400	0	52	0.0023	11.7600	2048	1000	13
NatGas	Pool Heat	0.0380	0	151	0.0023	11.7600	2048	1000	13



# Space heating and cooling

Residential Net Emissions Analysis Tool version 1.0 beta

Demand Intermediate Results Power Supply Economics placeholder1 placeholder2 Results

Housing Category:  Single-Family  Multi-Family  Mobile Home  Aggregate

Climate Zone:  6 Coastal  8 S. Near-Coastal  9 N. Near-Coastal  10 S. Inland  15 S. Desert  16 Mountain  All [CZ MAP](#)

Populate Values:

Hot water heating Kitchen Laundry Miscellaneous Pool Space heating and cooling Transportation

**BASELINE TECHNOLOGY MIX PARAMETERS** [Show Column Information](#)

Fuel	Technology	UEC	NOX EF	CO2e EF	Unit Cost	Install Cost	Lifetime	Penetration
Electric	Conventional Heat	454	0	0	739	1694	20	0.0330
Electric	Heat Pump	547	0	0	1977	3233	12.5000	0.0090
Electric	Auxiliary Heat	194	0	0	0	0	0	0.0040
Electric	Furnace Fan	151	0	0	193	450	10	0.6000
NatGas	Primary Heat	126	0.0066	11.7600	3040	1696	20	0.7690
NatGas	Auxiliary Heat	70	0.0066	11.7600	0	0	0	0.0120
Electric	Attic Ceiling Fan	184	0	0	90	471	20	0.1340
Electric	Central Air Conditioning	669	0	0	1524	1597	15	0.5240
Electric	Room Air Conditioning	223	0	0	300	276	15	0.2070
Electric	Evaporative Cooler	495	0	0	439	959	20	0.0500

**FUTURE TECHNOLOGY MIX**

Fuel	Technology	Penetration
Electric	Conventional Heat	0.0330
Electric	Heat Pump	0.0090
Electric	Auxiliary Heat	0.0040
Electric	Furnace Fan	0.6000
NatGas	Primary Heat	0.7690
NatGas	Auxiliary Heat	0.0120
Electric	Attic Ceiling Fan	0.1340
Electric	Central Air Conditioning	0.5240
Electric	Room Air Conditioning	0.2070
Electric	Evaporative Cooler	0.0500

**FUTURE MORE EFFICIENT TECHNOLOGY**

Fuel	Technology	Penetration	% adoption	UEC	NOX EF	CO2e EF	Unit Cost	Install Cost	Lifetime
Electric	Conventional Heat	0.0330	0	454	0	0	739	1694	20
Electric	Heat Pump	0.0090	0	547	0	0	1977	3233	12.5000
Electric	Auxiliary Heat	0.0040	0	194	0	0	0	0	0
Electric	Furnace Fan	0.6000	0	151	0	0	193	450	10
NatGas	Primary Heat	0.7690	0	126	0.0066	11.7600	3040	1696	20
NatGas	Auxiliary Heat	0.0120	0	70	0.0066	11.7600	0	0	0
Electric	Attic Ceiling Fan	0.1340	0	184	0	0	90	471	20
Electric	Central Air Conditioning	0.5240	0	669	0	0	1524	1597	15
Electric	Room Air Conditioning	0.2070	0	223	0	0	300	276	15
Electric	Evaporative Cooler	0.0500	0	495	0	0	439	959	20

Table values can be edited manually. Tools to implement common editing scenarios are provided:

**Replace Technology Tool**

Select technology to phase-out:

Select technology to use instead:

**Adopt More Efficient Technology**

Select technology to improve efficiency:

% of households with technology in the future that will adopt more efficient version:

Use FUTURE MORE EFFICIENT TECHNOLOGY table to specify parameters of more efficient tech.



# Transportation

Residential Net Emissions Analysis Tool version 1.0 beta

Demand Intermediate Results Power Supply Economics placeholder1 placeholder2 Results

Housing Category:  Single-Family  Multi-Family  Mobile Home  Aggregate

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Populate Values:

Hot water heating Kitchen Laundry Miscellaneous Pool Space heating and cooling **Transportation**

**BASELINE TECHNOLOGY MIX PARAMETERS** [Show Column Information](#)

Fuel	Technology	UEC	NOX EF	CO2e EF	Unit Cost	Install Cost	Lifetime	Penetration
Gasoline	Light Duty Vehicle	509	0.0060	18.6560	25204	0	13	1.0490
Diesel	Light Duty Vehicle	419	0.0130	22.2220	37849	0	19	0.0080
Electric	Light Duty Vehicle	4975	0	0	39859	0	16	0.0080

Table values can be edited manually. Tools to implement common editing scenarios are provided.

**Replace Technology Tool**

Select technology to phase-out: Gasoline Light Duty Vehicle

Select technology to use instead: Diesel Light Duty Vehicle

**Adopt More Efficient Technology**

Select technology to improve efficiency: Gasoline Light Duty Vehicle

% of households with technology in the future that will adopt more efficient version: 0

Use FUTURE MORE EFFICIENT TECHNOLOGY table to specify parameters of more efficient tech.

**ADVANCE TO NEXT**

**FUTURE TECHNOLOGY MIX**

Fuel	Technology	Penetration
Gasoline	Light Duty Vehicle	1.0490
Diesel	Light Duty Vehicle	0.0080
Electric	Light Duty Vehicle	0.0080

**FUTURE MORE EFFICIENT TECHNOLOGY**

Fuel	Technology	% adoption	UEC	NOX EF	CO2e EF	Unit Cost	Install Cost	Lifetime
Gasoline	Light Duty Vehicle	0	509	0.0060	18.6560	25204	0	13
Diesel	Light Duty Vehicle	0	419	0.0130	22.2220	37849	0	19
Electric	Light Duty Vehicle	0	4975	0	0	39859	0	16



# Technology Mix Editing Tools

Residential Net Emissions Analysis Tool version 1.0 beta

Demand Intermediate Results Power Supply Economics placeholder1 placeholder2 Results

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Populate Values:

Hot water heating Kitchen Laundry Miscellaneous Pool Space heating and cooling **Transportation**

**BASELINE TECHNOLOGY MIX PARAMETERS** [Show Column Information](#)

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**FUTURE TECHNOLOGY MIX**

Fuel	Technology	Penetration
Gasoline	Light Duty Vehicle	1.0490
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**FUTURE MORE EFFICIENT TECHNOLOGY**

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Gasoline	Light Duty Vehicle	0	509	0.0060	18.6560	25204	0	13
Diesel	Light Duty Vehicle	0	419	0.0130	22.2220	37849	0	19
Electric	Light Duty Vehicle	0	4975	0	0	39859	0	16

**User can edit values manually or use these tools for common editing scenarios**

Table values can be edited manually. Tools to implement common editing scenarios are provided:

**Replace Technology Tool**

Select technology to phase-out: Gasoline Light Duty Vehicle

Select technology to use instead: Diesel Light Duty Vehicle

**Adopt More Efficient Technology**

Select technology to improve efficiency: Gasoline Light Duty Vehicle

% of households with technology in the future that will adopt more efficient version: 0

Use FUTURE MORE EFFICIENT TECHNOLOGY table to specify parameters of more efficient tech.



# Baseline Demand

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- For all electric appliances,  $i$ :

$$Elec_{Base,i,h} = Penetration_{Base,i} \times UEC_{Base,i} \times Load_h$$

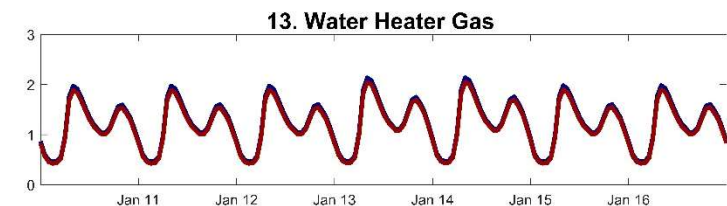
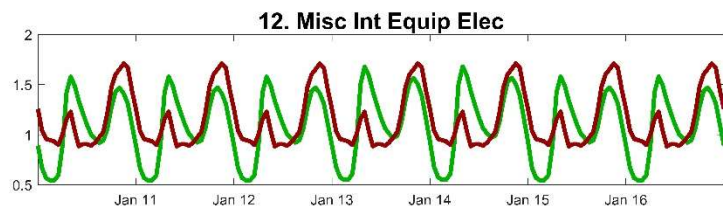
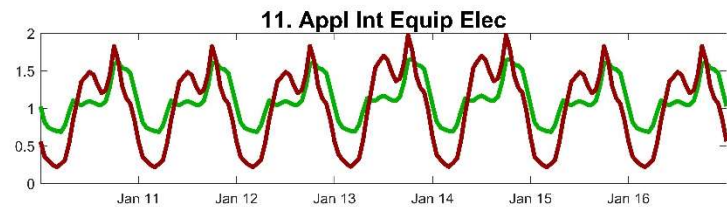
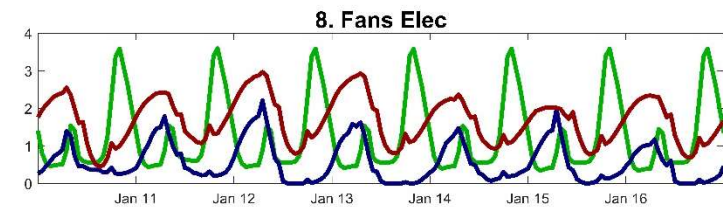
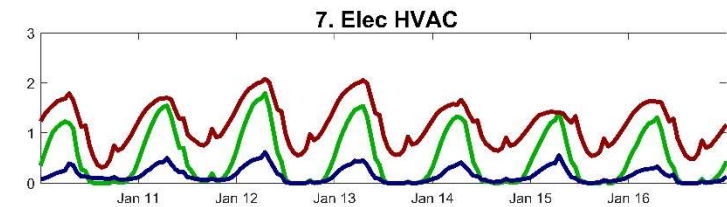
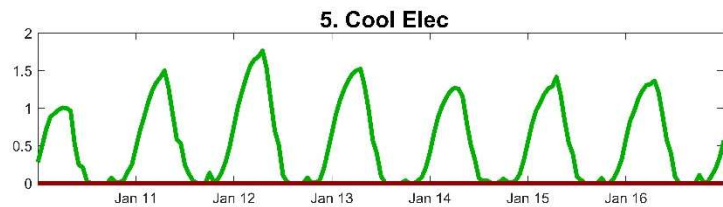
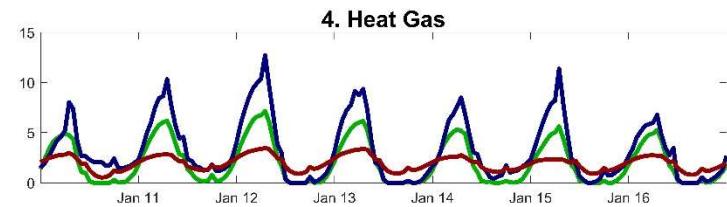
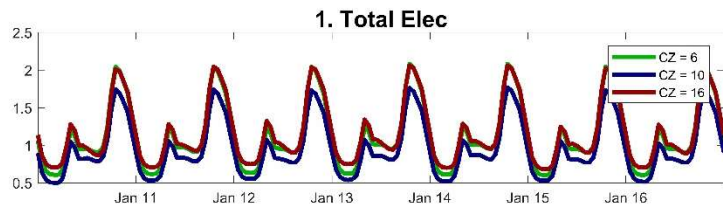
- For all gas appliances,  $j$ :

$$Gas_{Base,j,h} = Penetration_{Base,j} \times UEC_{Base,j} \times Load_h$$

Hourly Loads,  $Load_h$ , are obtained from Building America House Simulation Protocol, NREL 2010

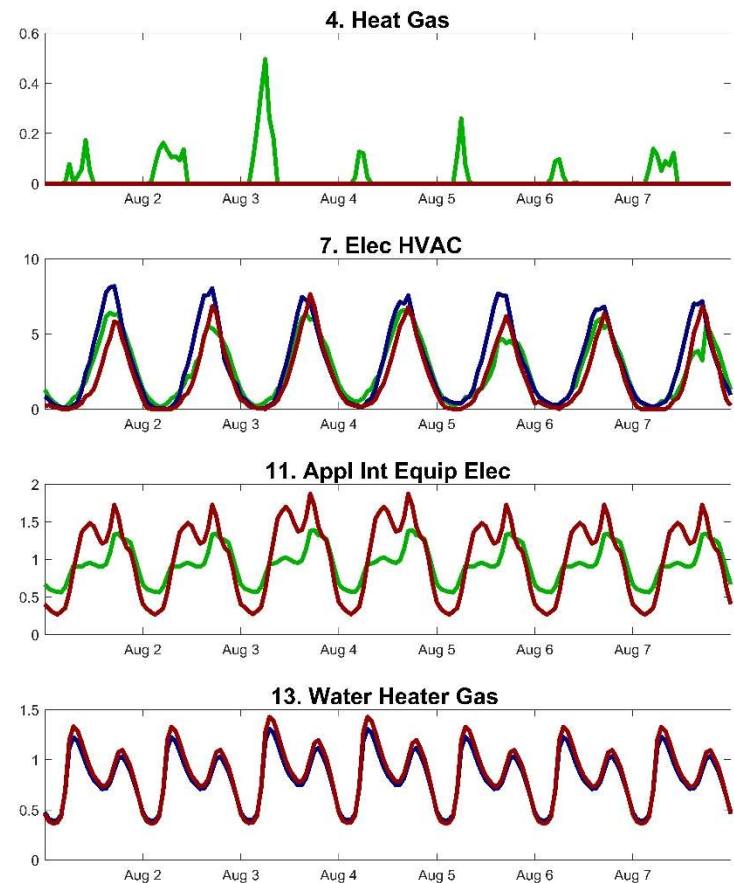
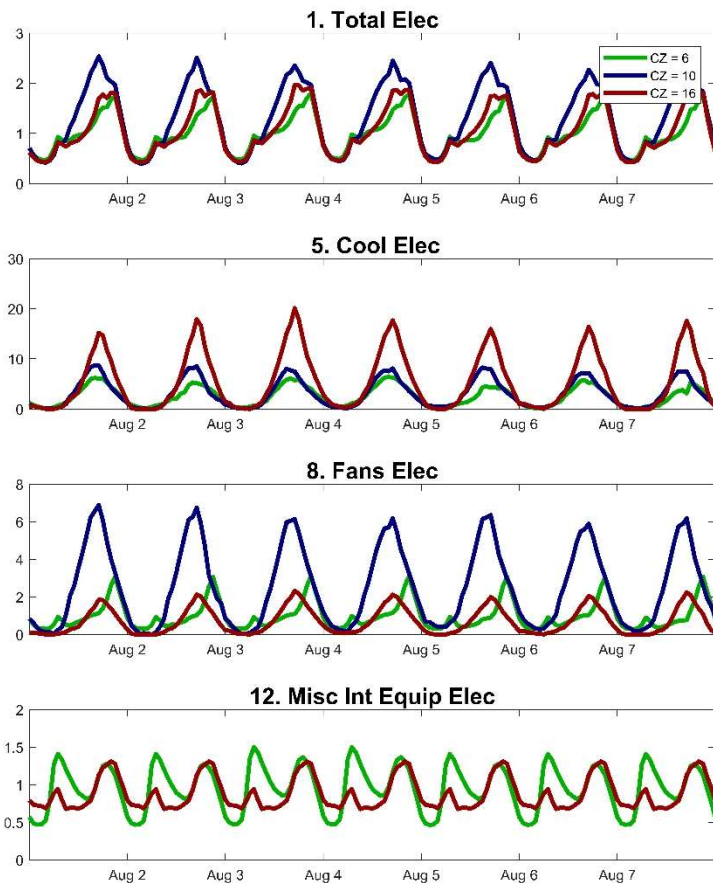


# Hourly Loads by Climate Zone – January





# Hourly Loads by Climate Zone – August



# Future Case Demand

---

- For all electric appliances,  $i$ :

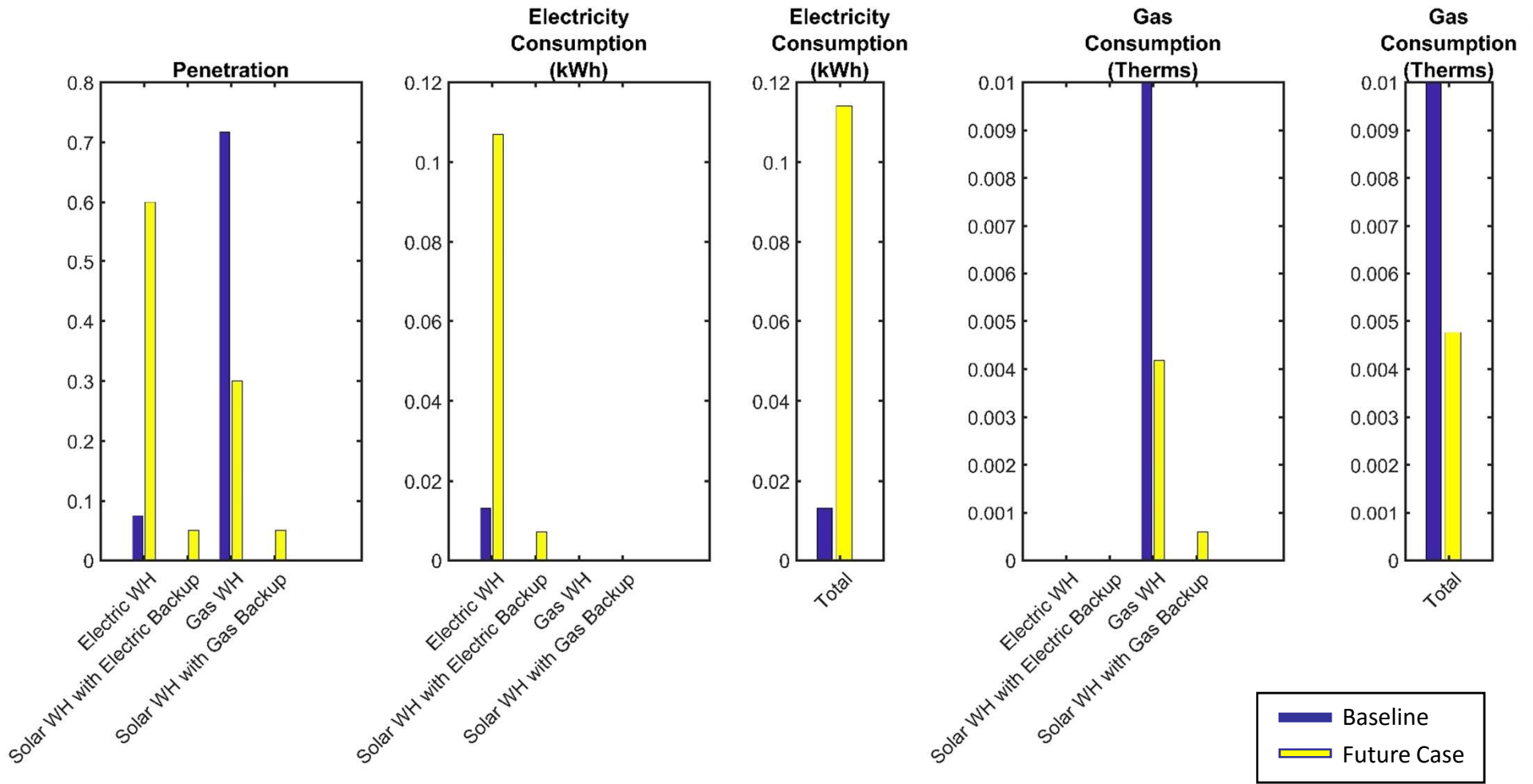
$$\begin{aligned} Elec_{Future,i,h} = & \\ & ( Penetration_{Future,i} \times UEC_{Base,i} \times (1 - \%Adoption_i) \\ & + Penetration_{Future,i} \times UEC_{Future,i} \times \%Adoption_i ) \times Load_h \end{aligned}$$

- For all gas appliances,  $j$ :

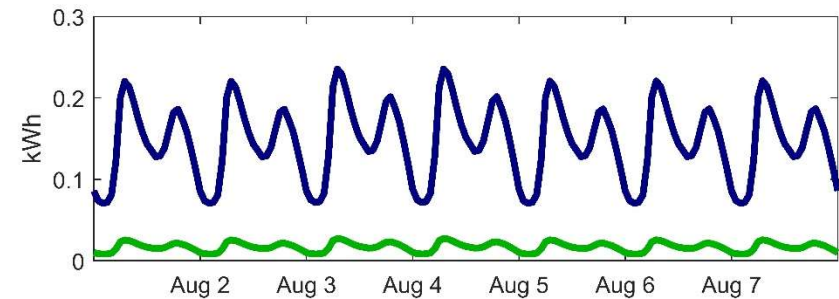
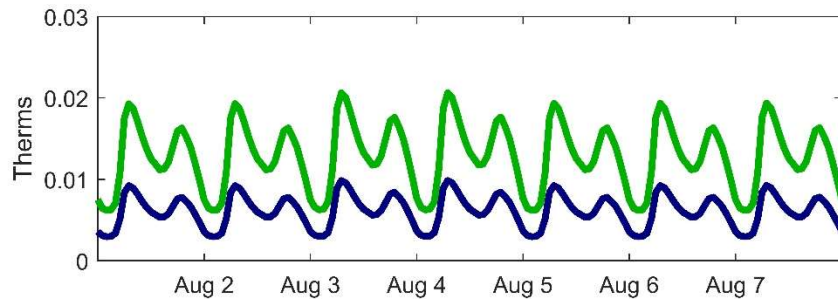
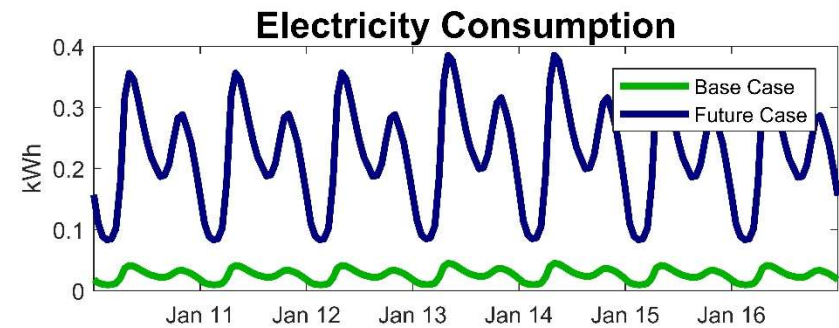
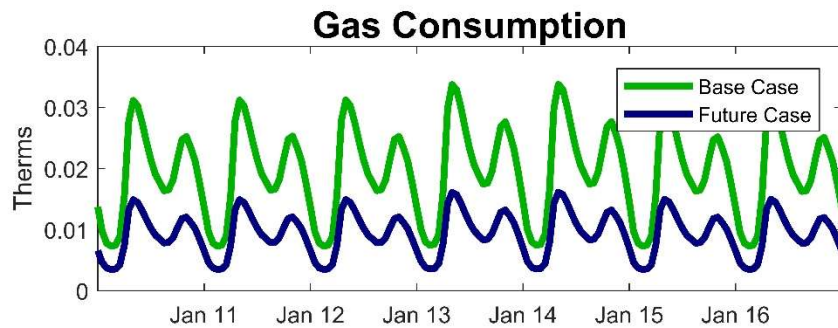
$$\begin{aligned} Gas_{Future,j,h} = & \\ & ( Penetration_{Future,j} \times UEC_{Base,j} \times (1 - \%Adoption_j) \\ & + Penetration_{Future,j} \times UEC_{Future,j} \times \%Adoption_j ) \times Load_h \end{aligned}$$



# Example Calculation: Water Heating



# Example Calculation: Water Heating



# Emissions

---

- Baseline emissions:

$$Emissions_{Base,j,h,pol} = Gas_{Base,j,h} \times EF_{Base,j,pol}$$

- Future emissions:

$$Emissions_{Future,j,h} = \\ \left( Penetration_{Future,j} \times UEC_{Base,j} \times (1 - \%Adoption_j) \times EF_{Base,j,pol} \right. \\ \left. + Penetration_{Future,j} \times UEC_{Future,j} \times \%Adoption_j \times EF_{Future,j,pol} \right) \times Load_h$$



# Costs

---

- Baseline costs:

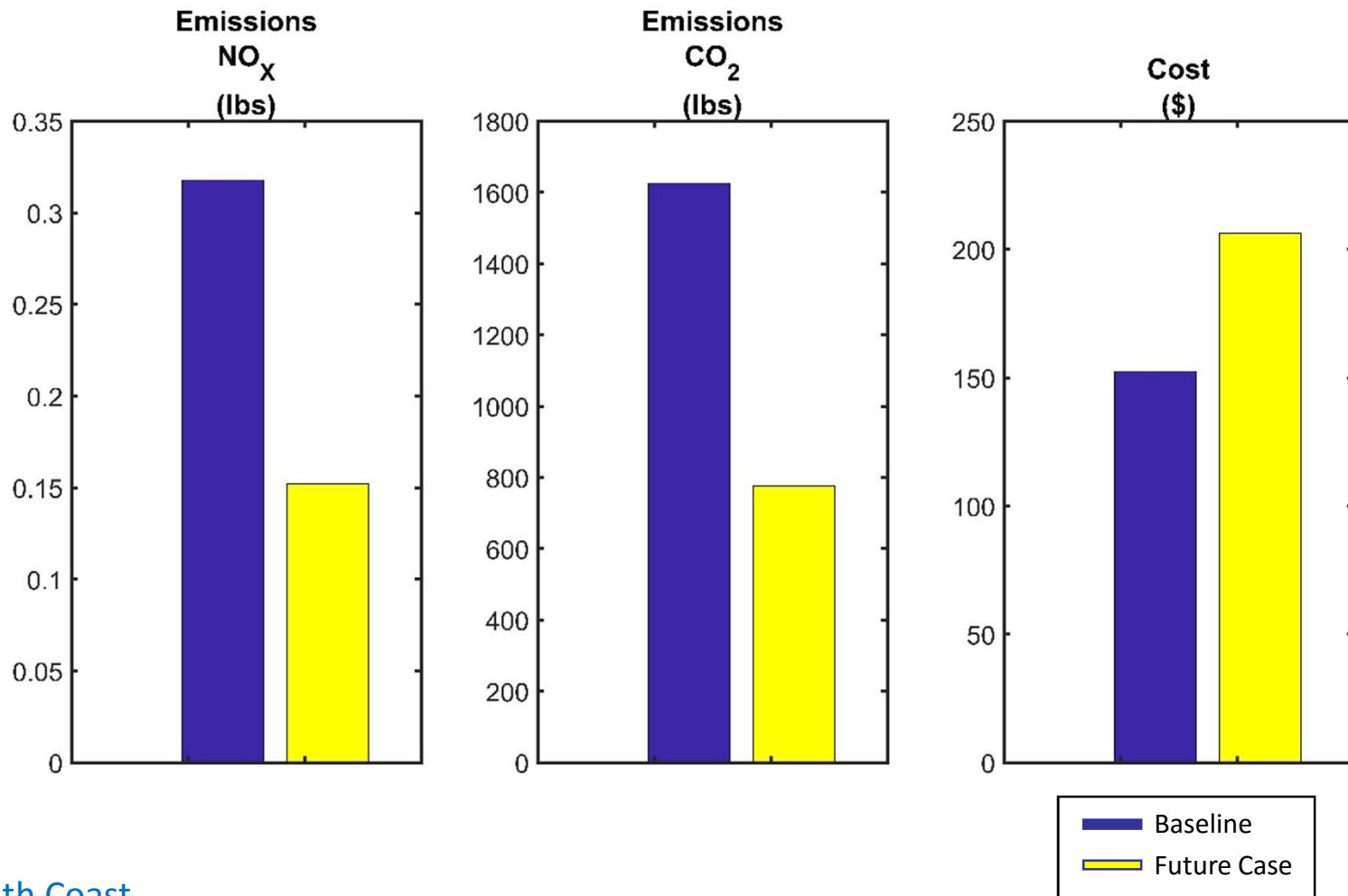
$$\begin{aligned} &Costs_{Base,i} \\ &= Penetration_{Base,i} \times (InstallCost_{Base,i} + UnitCost_{Base,i}) / lifetime_{Base,i} \end{aligned}$$

- Future costs:

$$\begin{aligned} &Costs_{Future,i} = \\ &( Penetration_{Future,i} \times (InstallCost_{Base,i} + UnitCost_{Base,i}) / lifetime_{Base,i} \\ &\times (1 - \%Adoption_i) + Penetration_{Future,i} \\ &\times (InstallCost_{Future,i} + UnitCost_{Future,i}) / lifetime_{Future,i} \times \%Adoption_i ) \end{aligned}$$



# Example Calculation: Water Heating



# Implementation of Distributed PV

Residential Net Emissions Analysis Tool version 1.0 beta

Demand | Intermediate Results | **Power Supply** | Economics | placeholder1 | placeholder2 | Results

### Natural Gas Production and Transport

### Electricity Generation

### Distributed Solar Photovoltaics

**Implement Rooftop Solar PV using PVWatts**

[Rooftop Solar PV Module Documentation](#)

**For Advanced Users**

Solar Cost Function:  $COST = 4466.83 * X + 1859.02$  where "X" is defined as the panel size in kW DC under standard test conditions.

Reset to Default | Test Function | More Information

Module Type: **Standard** | Rooftop Area Availability Ratio: **0.75**

System Loss Value: **0.14**

Inverter Efficiency [%]: **96**

DC to AC Size Ratio: **1.1**

Panel Tilt [degrees]: **20**

Reset to Default | More Information

### Residential Battery Storage

**Implement Residential Battery using PVWatts Battery Model**

[Residential Battery Module Documentation](#)

**For Advanced Users**

Battery System (all fields editable)	<input type="radio"/> Battery Setup A <input type="radio"/> Battery Setup B <input type="radio"/> Battery Setup C	Cost For First Battery \$	<input type="text" value="6200"/>	Installation Cost \$	<input type="text" value="1400"/>
		Cost Per Additional Battery \$	<input type="text" value="5500"/>	Lifetime [years]	<input type="text" value="10"/>

Battery Capacity [kW-hr] (for each battery):  | Battery Chemistry: **Lithium Ion**

Battery Power [kW]:  | Battery Dispatch: **Peak Shaving (look behind)**

Reset to Default | More Information

[RETURN TO PREVIOUS](#) | [ADVANCE TO NEXT](#)





# Implementation of Distributed PV

## Distributed Solar Photovoltaics

**Implement Rooftop Solar PV using PVWatts**

[Rooftop Solar PV Module Documentation](#)

**For Advanced Users**

Solar Cost Function:  $COST = 4466.83 * X + 1859.02$  where "X" is defined as the panel size in kW DC under standard test conditions.

[Reset to Default](#)  
[Test Function](#)  
[More Information](#)

Module Type: **Standard** (dropdown menu)

Rooftop Area Availability Ratio:

System Loss Value:

Inverter Efficiency [%]:

DC to AC Size Ratio:

Panel Tilt [degrees]:

[Reset to Default](#)  
[More Information](#)



# Implementation of Distributed PV

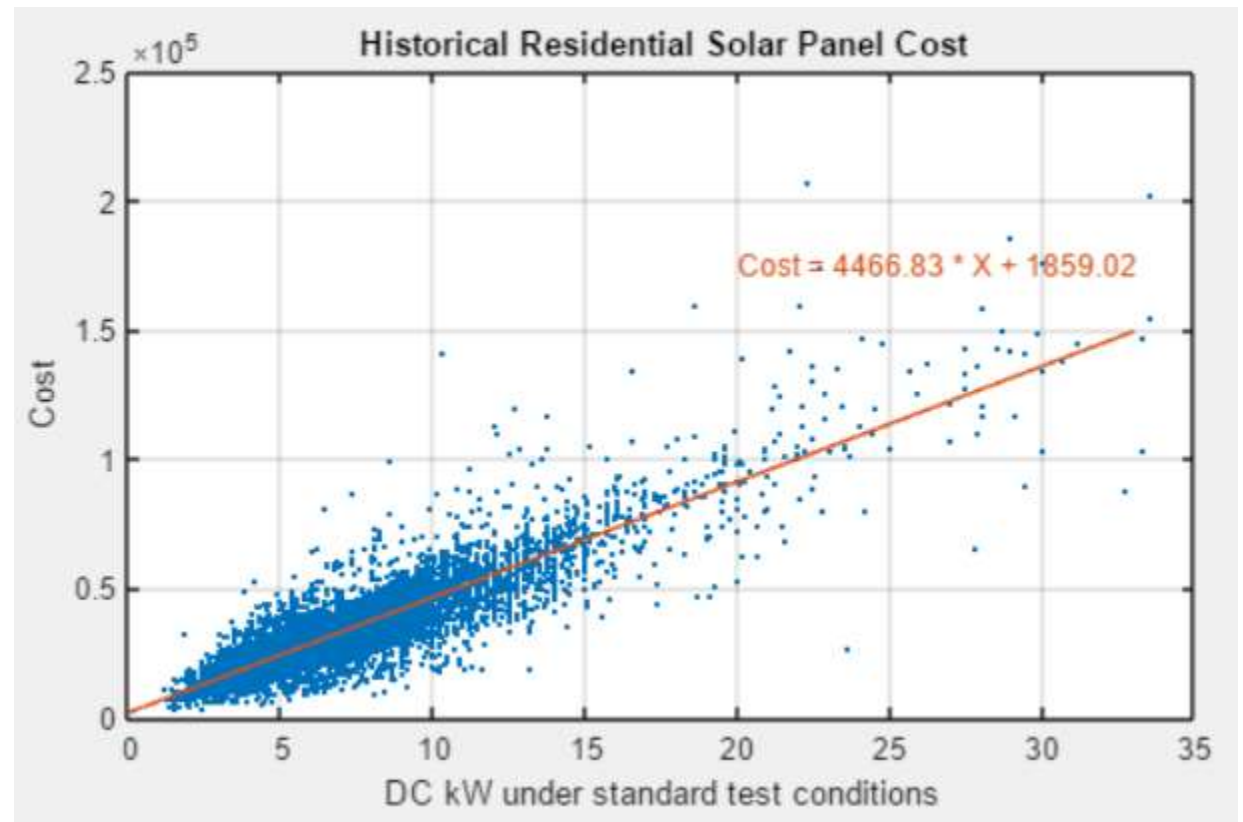
---

- How much panel area is available to the average single family and mobile home household in each climate zone?
- How much electricity can be generated by the average single family and mobile home household in each climate zone?
  - NREL's PVWatts used for calculation
- How many panels will minimize cost (construction and electricity bills)?



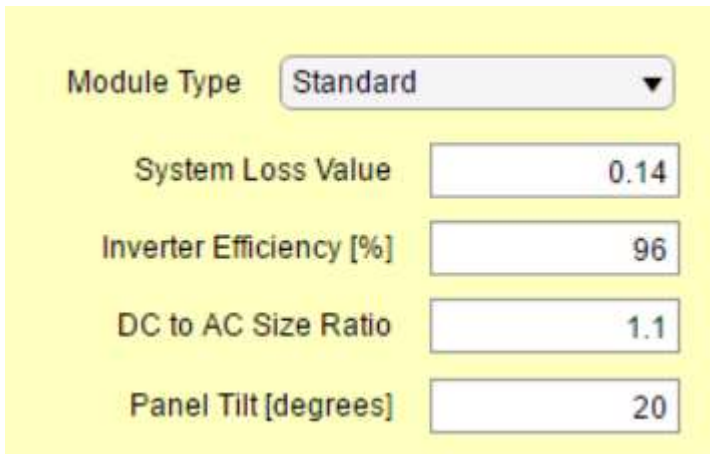
# Solar Cost Function

- Function can be edited by advanced users
- CA distributed generation statistics
- Residential PV installations in SCE territory completed after 1/1/2014 were analyzed



# Solar PV Module Input Parameters

(for advanced users)



Module Type	Standard
System Loss Value	0.14
Inverter Efficiency [%]	96
DC to AC Size Ratio	1.1
Panel Tilt [degrees]	20

- Module type choices include “standard”, “premium”, and “thin-film”. This determines the panel efficiency and the power dependence on temperature
- System Loss Value is the product of several performance losses, i.e. shading, soiling, age, etc.
- Inverter Efficiency is the nominal rated DC-to-AC conversion efficiency
- Panel tilt is the angle from horizontal of all the panels in the PV array

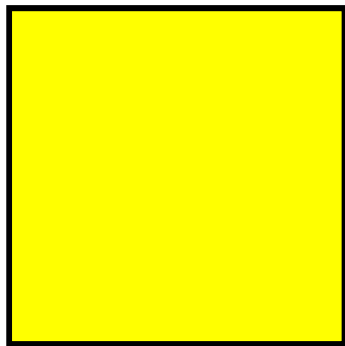


# Solar PV Module Input Parameters

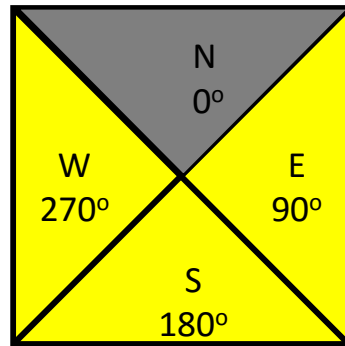
(for advanced users)

Rooftop Area Availability Ratio

Aerial view of average house



Low slope  
Slope < 2:12



High slope  
Slope > 2:12

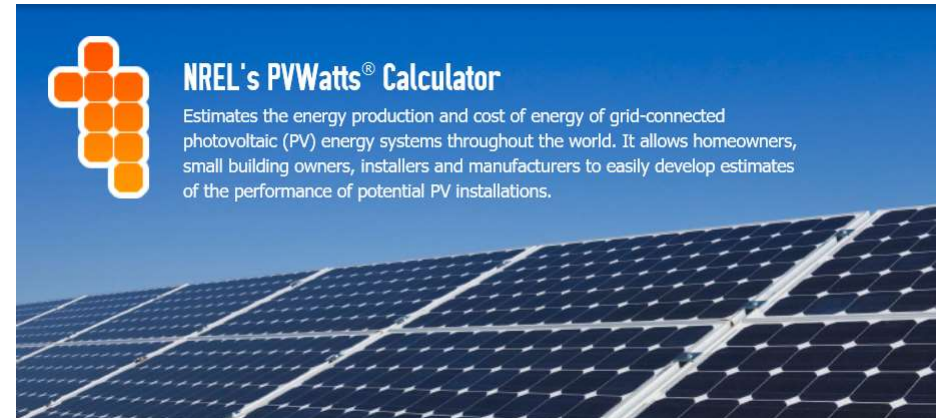
- Maximum panel area / area of the average rooftop footprint
- Only applied to flat roofs and non-North facing sloped rooftops
- Takes into account space needed for roof vents, skylights, etc
- Only a minor impact on final calculation—used to determine theoretical maximum panel area on each building



# Calculation of Solar PV Generation

---

- Based on PVWatts from NREL
- PVWatts is typically applied for individual buildings
- We apply PVWatts on a regional basis
- Calculate PV Generation for single family and mobile homes



# Calculation of Solar PV Generation

- Hourly solar resource and meteorological data
  - Representative Typical Meteorological Year 3 measurement station selected for each climate zone
- Average high-slope and low-slope rooftop area of single family and mobile homes in each climate zone used to determine max panel area
  - Used building footprint data from the US Army Corps of Engineers
  - Used high-resolution land use data from SCAG

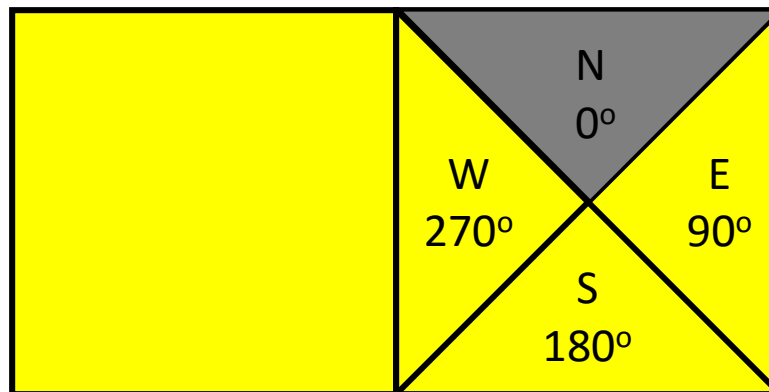
Average area [m <sup>2</sup> ]	CZ 6	CZ 8	CZ 9	CZ 10	CZ 15	CZ 16
single family high slope	177	172	168	178	178	174
single family low slope	159	139	164	145	145	152
mobile home high slope	136	126	130	141	141	133
mobile home low slope	152	135	172	154	154	153



# Calculation of Solar PV Generation

- Max PV generation for single family and mobile homes in each climate zone calculated with 4 simulations

Aerial view of average house



Low slope  
Slope < 2:12

High slope  
Slope > 2:12

1. (Low slope area) x (rooftop area availability fraction) facing 180°
2.  $\frac{1}{4}$  x (high slope area) x (rooftop area availability fraction) with azimuth of 270°
3.  $\frac{1}{4}$  x (high slope area) x (rooftop area availability fraction) with azimuth of 180°
4.  $\frac{1}{4}$  x (high slope area) x (rooftop area availability fraction) with azimuth of 90°





# Implementation of Solar PV Results

---

- Hourly solar generation electricity profiles are subtracted from demand profiles to determine electricity needed from the grid
- Costs of the panel installation are calculated with the cost function and electricity costs are calculated with the electricity rates
- Process is repeated with several panel areas multipliers (0.1, 0.2,...) to determine panel area where costs are minimized



U.S. Air Force photo by Kenji Thuloweit



# Topics for Open Discussion

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- Documentation embedded in the software vs. a large documentation file
- Feedback on this meeting (structure, level of detail, etc.)



Pixabay.com



# Public Comments

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[blog.cleanenergy.org](http://blog.cleanenergy.org)

