Task 48
Quality Assurance and Support Measures for Solar Cooling

SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

Potential of Solar Thermal Cooling Technology in USA




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Bethpage, New York – October 29, 2013

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EMCG

Energy Management Consulting Group (EMCG)

International Energy Agency Solar Heating and Cooling Program

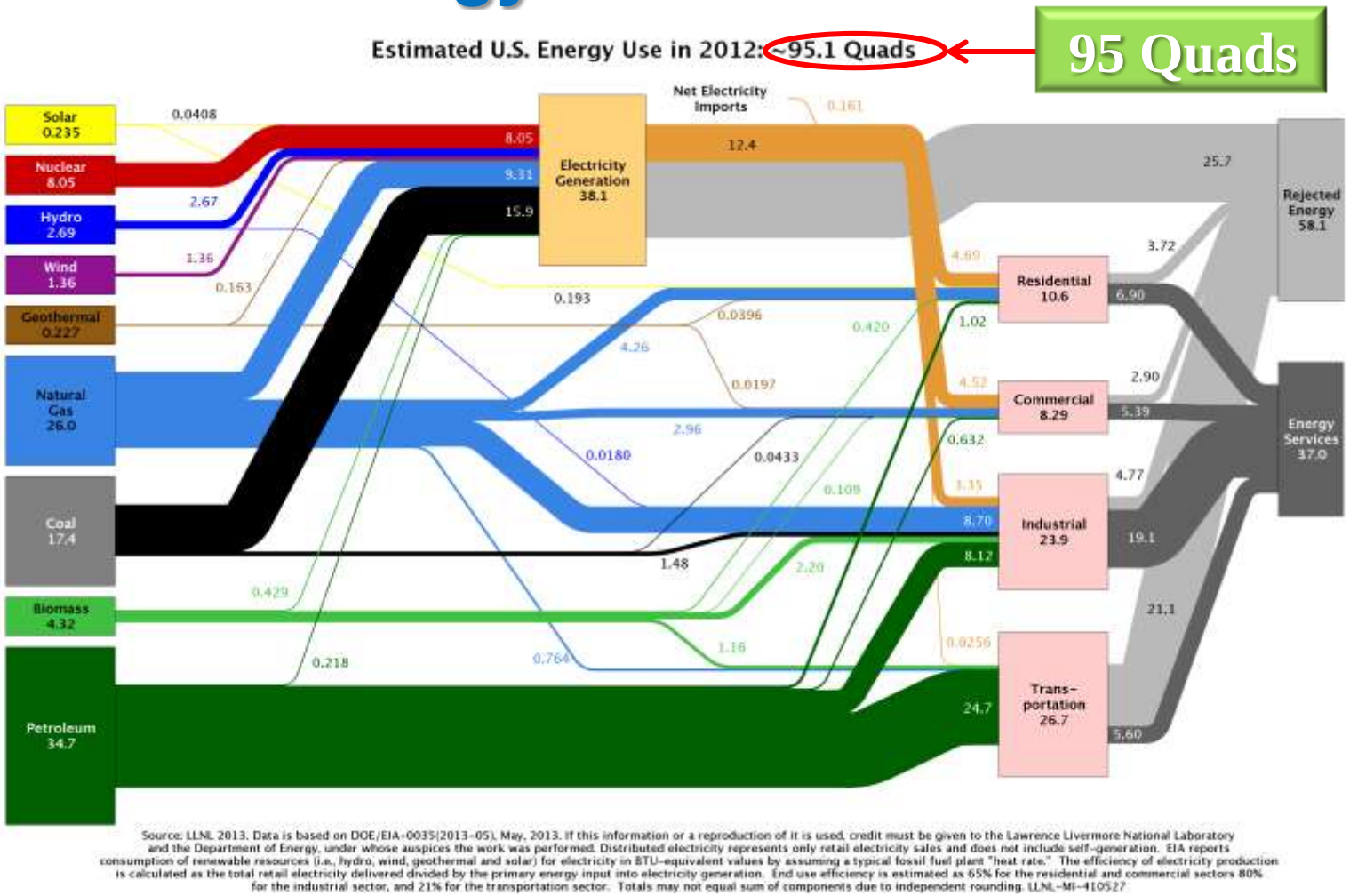
IEA SHC TASK 48:

"Quality assurance and support measures for solar cooling"

Duration: 3.5 years (October 2011 - March 2015)

- Subtask A: Quality procedure on component level
- Subtask B: Quality procedure on system level
- Subtask C: Market support measures
- Subtask D: Dissemination and policy advice

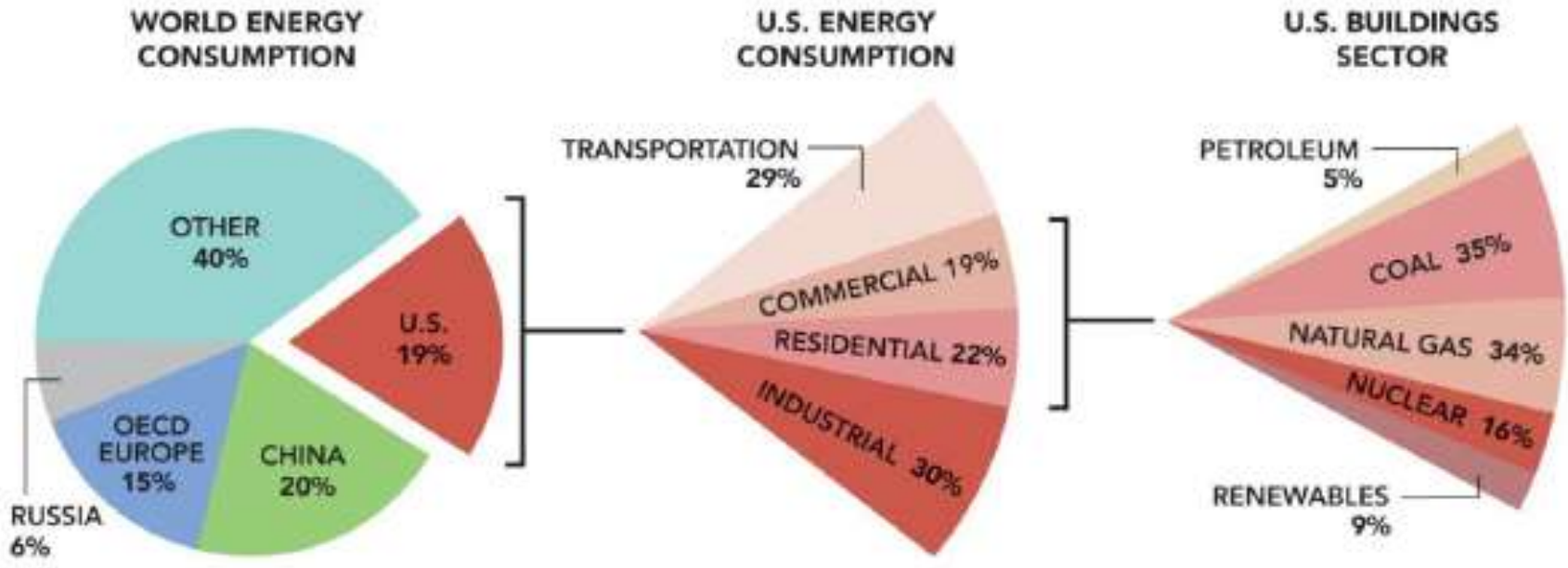
U.S. Energy Flow Trends - 2012



Source: LLNL 2013. Data is based on DOE/EIA-0035(2013-05), May, 2013. If this information or a reproduction of it is used, credit must be given to the Lawrence Livermore National Laboratory and the Department of Energy, under whose auspices the work was performed. Distributed electricity represents only retail electricity sales and does not include self-generation. EIA reports consumption of renewable resources (i.e., hydro, wind, geothermal and solar) for electricity in BTU-equivalent values by assuming a typical fossil fuel plant "heat rate." The efficiency of electricity production is calculated as the total retail electricity delivered divided by the primary energy input into electricity generation. End use efficiency is estimated as 65% for the residential and commercial sectors 80% for the industrial sector, and 21% for the transportation sector. Totals may not equal sum of components due to independent rounding. LLNL-MI-410527

Source: Lawrence Livermore National Laboratory

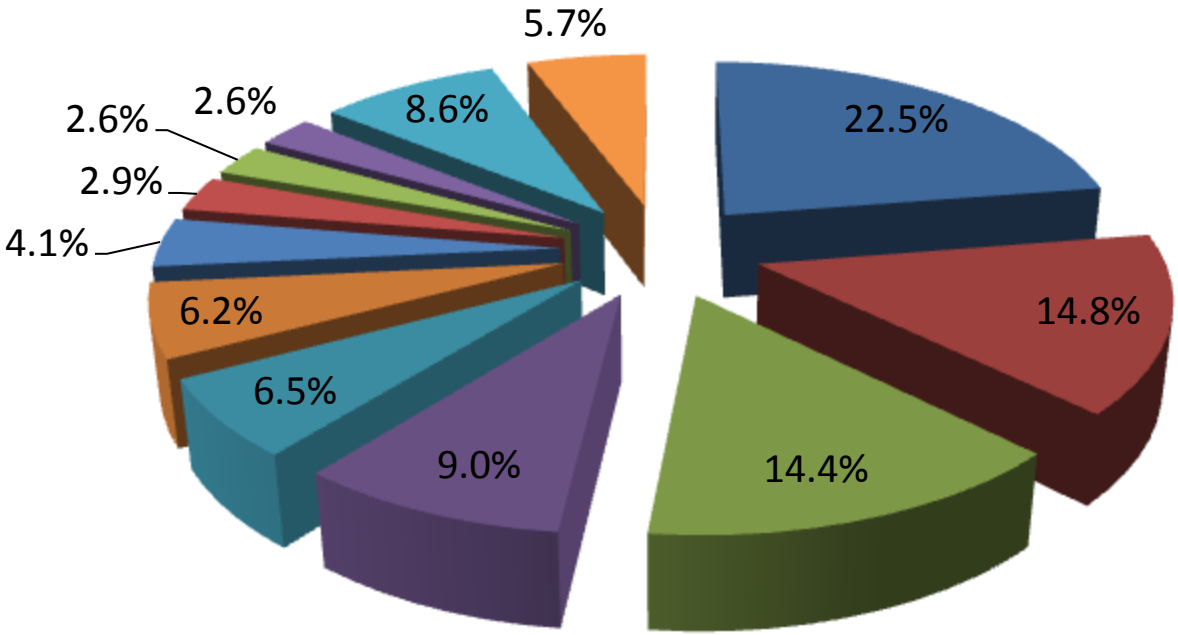
World Energy Consumption - 2010



- U.S. consumed 97.8 quads of energy in 2010, which represented 19% of global consumption.
- Buildings sector alone accounted for about 41% of primary energy consumption.

Source: 2011 Building Energy Data Book by U.S. DOE/EERE

2010 U.S. Buildings Energy End-Use Splits



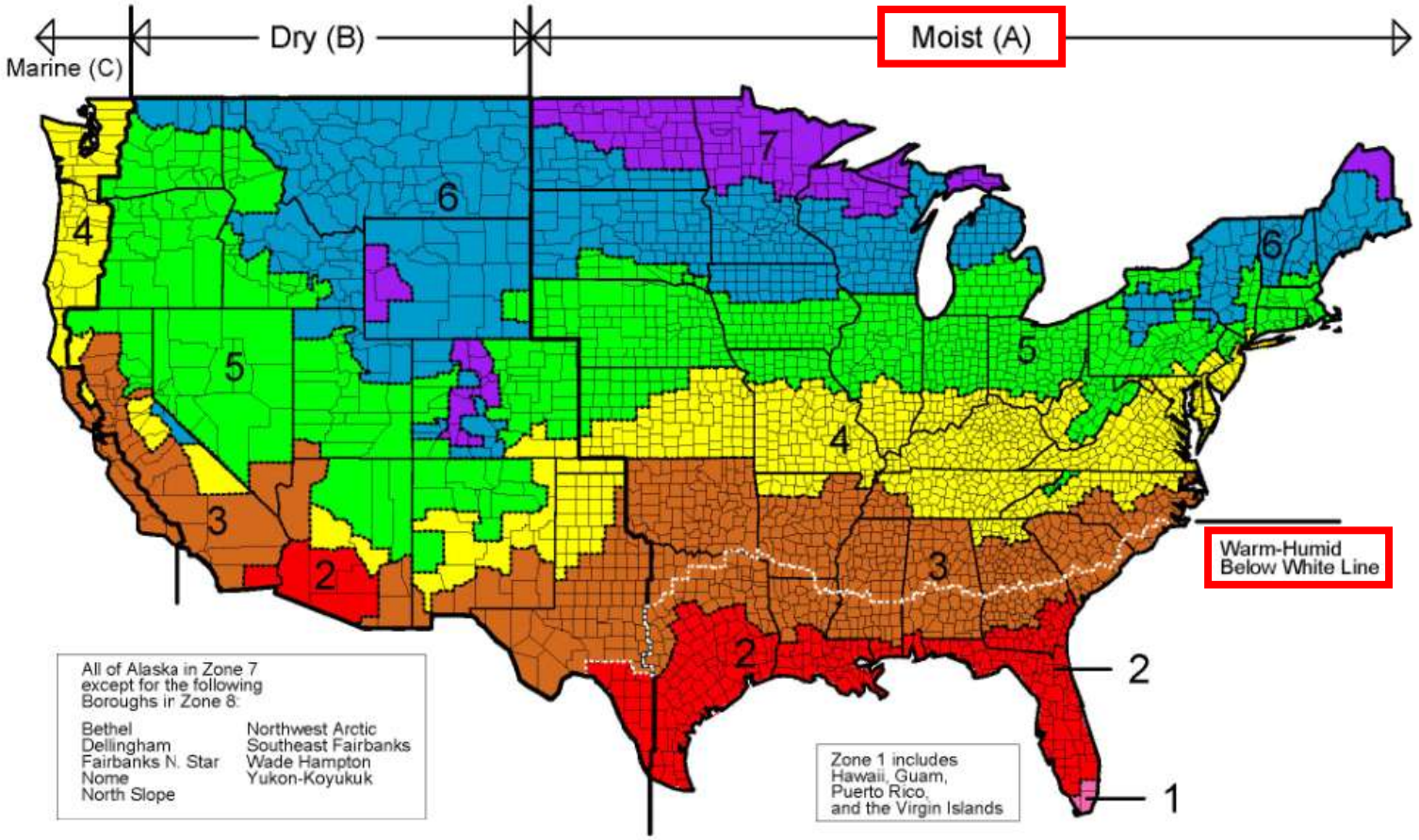
Space Heating: 22.5%
+
Space Cooling: 14.8%
+
Water Heating: 9.0%

Total: 46% of US Buildings Energy Use

Space Heating | Space Cooling | Lighting | Water Heating
Refrigeration | Electronics | Ventilation | Computers
Cooking | Wet Cleaning | Other | Adjust to SEDS

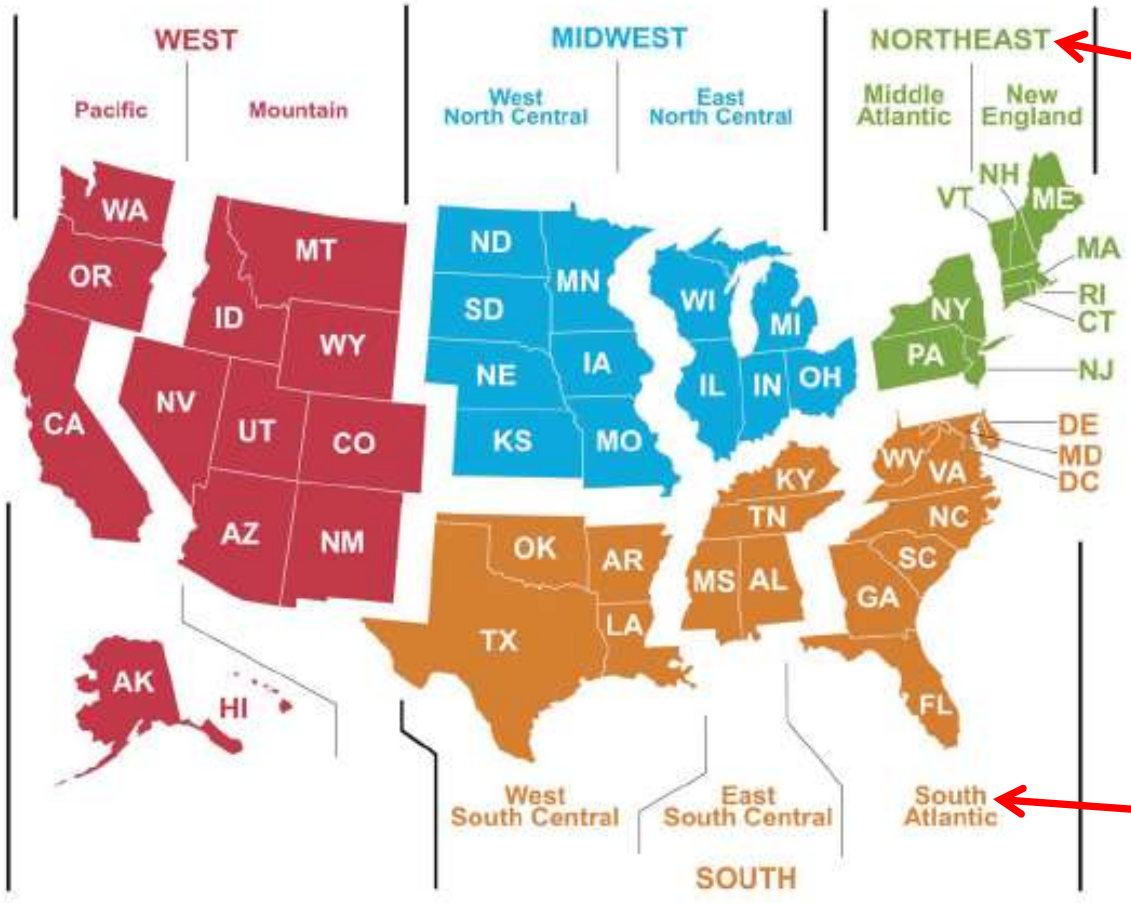
Source: 2011 Building Energy Data Book by U.S. DOE/EERE, derived from Table 1.1.4

United States Climate Zones



Source: ANSI/ASHRAE Standard 62.2

U.S. Census Regions and Divisions

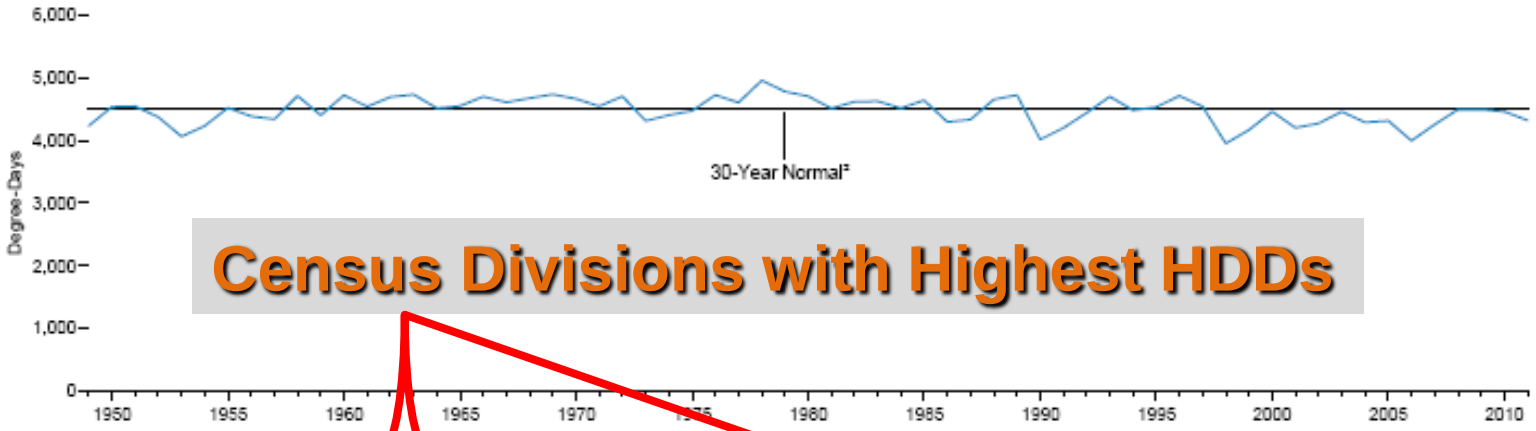


Census Region

Census Division

Source: U.S. Department of Commerce, Bureau of the Census

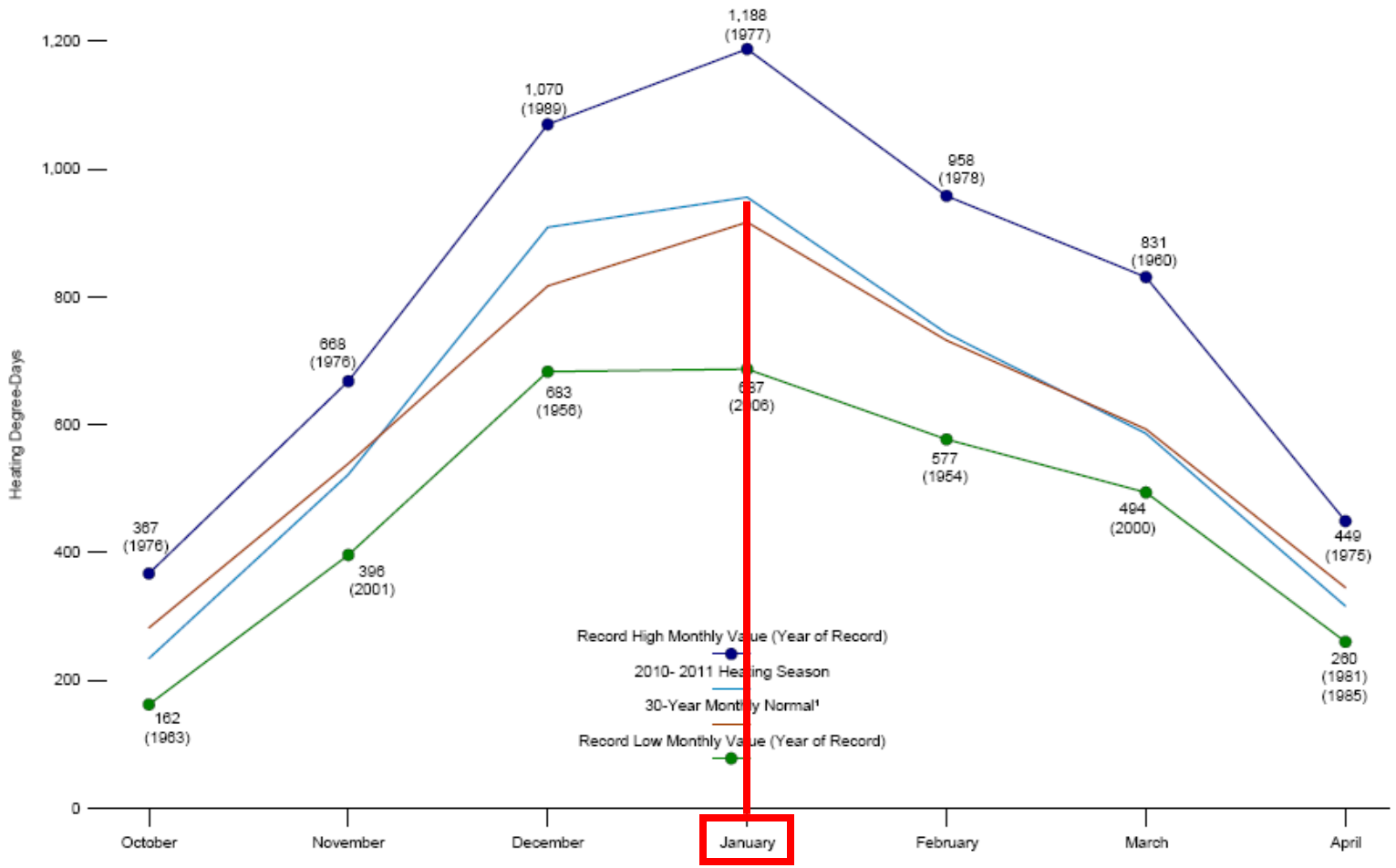
U.S. Heating Degree-Days: 1949 - 2011



Census Divisions with Highest HDDs

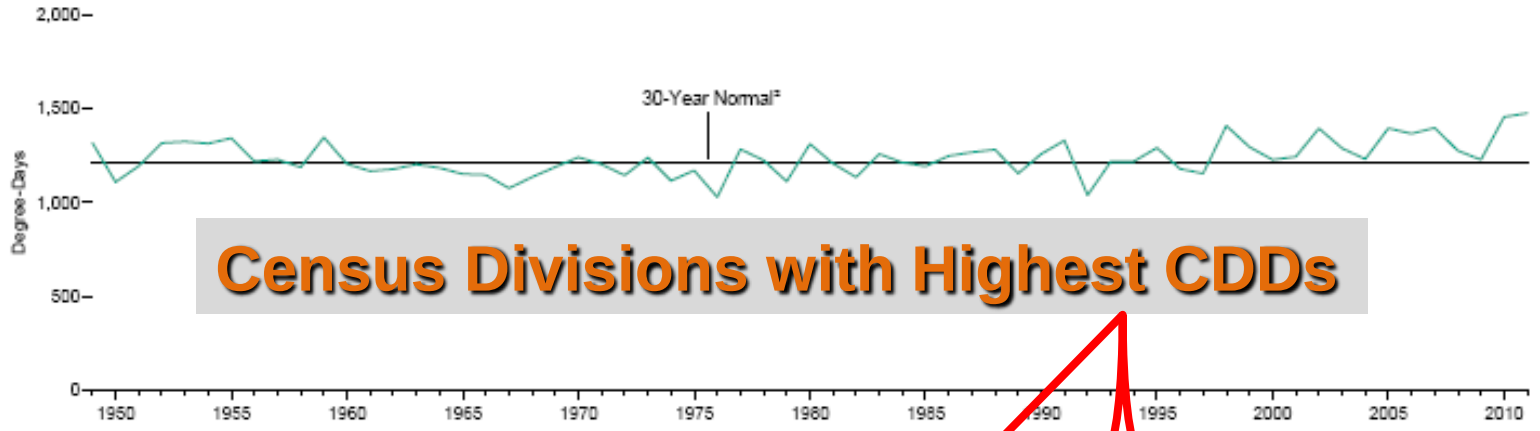
Source: U.S. Energy Information Administration / Annual Energy Review 2011

U.S. HDD by Month: 1949 - 2011

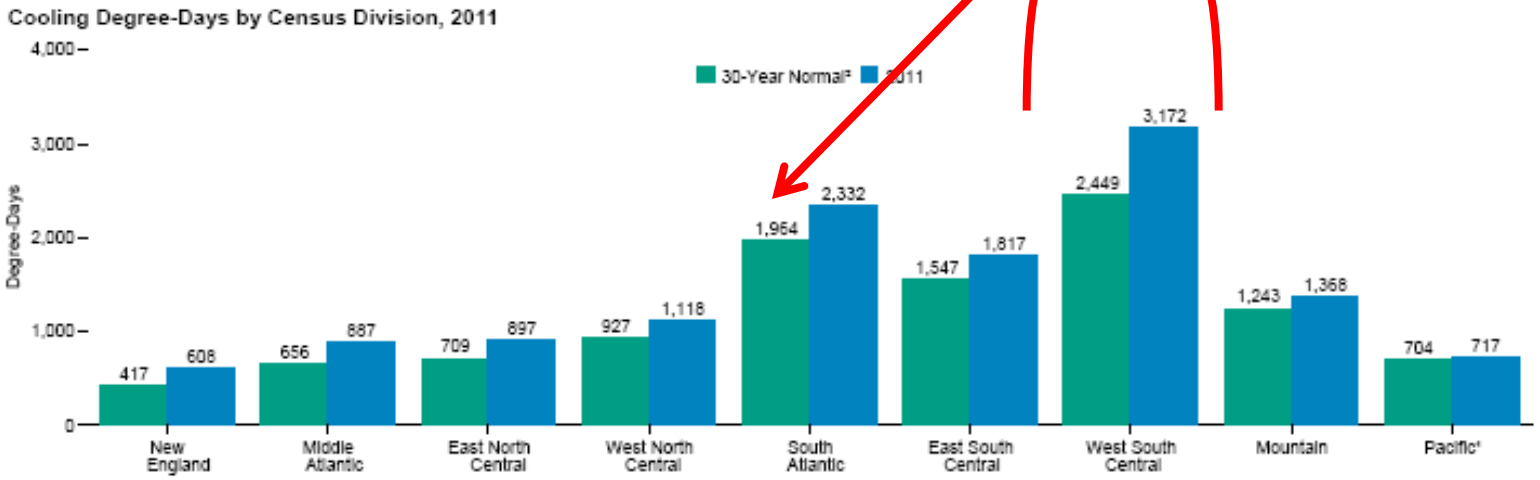


Source: U.S. Energy Information Administration / Annual Energy Review 2011

U.S. Cooling Degree-Days: 1949 - 2011

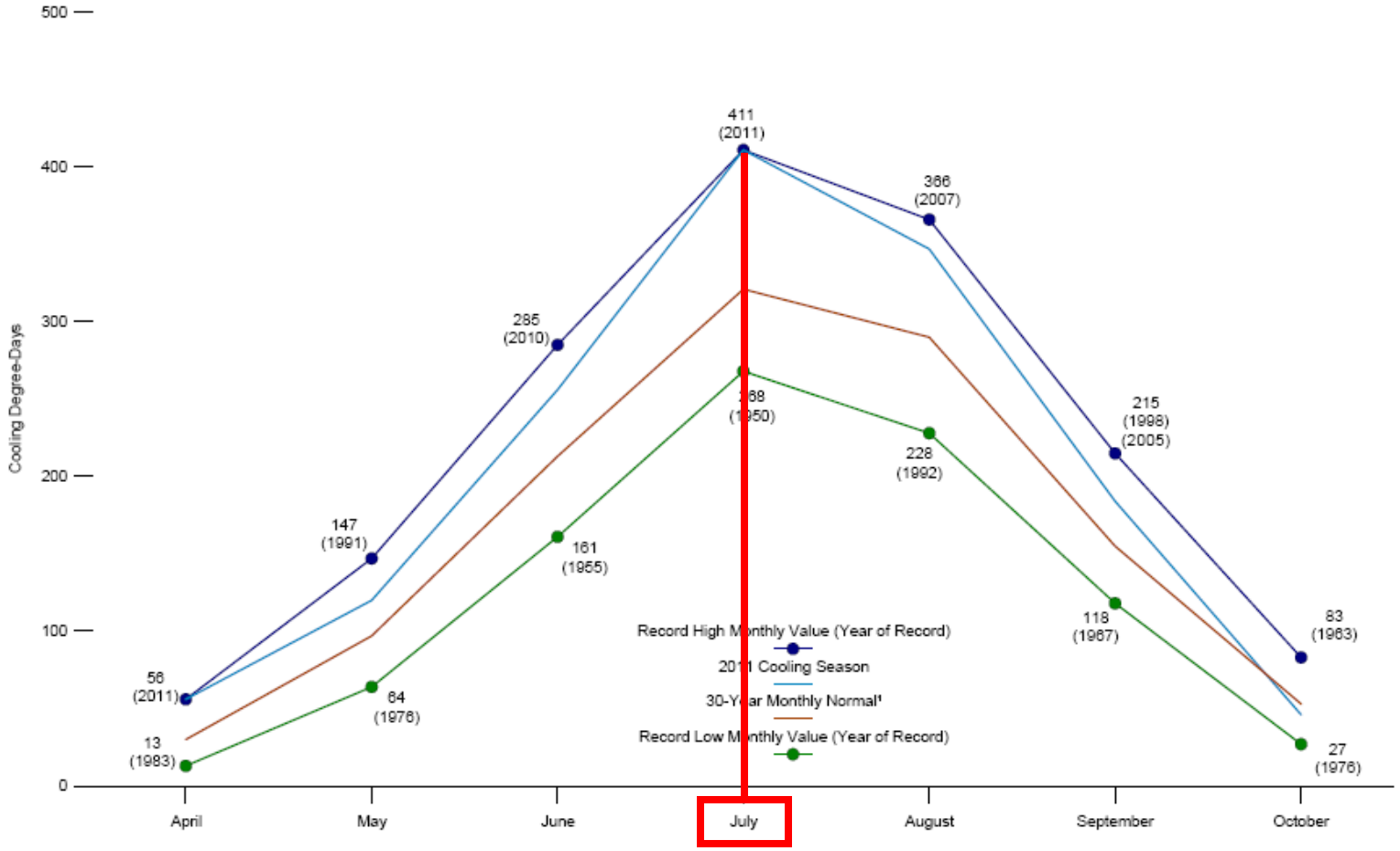


Census Divisions with Highest CDDs



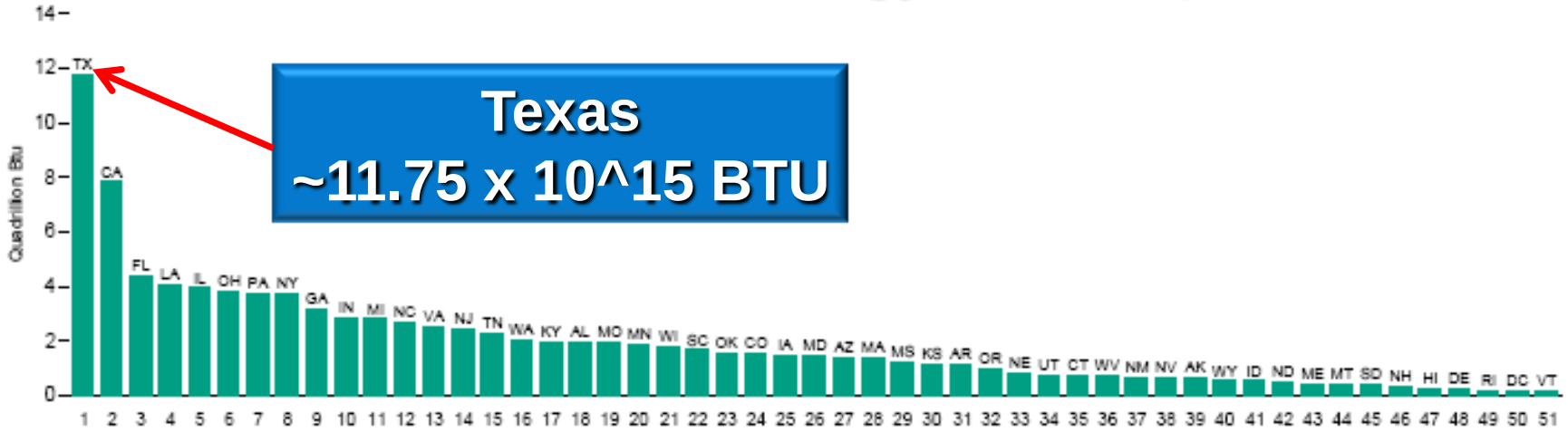
Source: U.S. Energy Information Administration / Annual Energy Review 2011

U.S. CDD by Month: 1949 - 2011

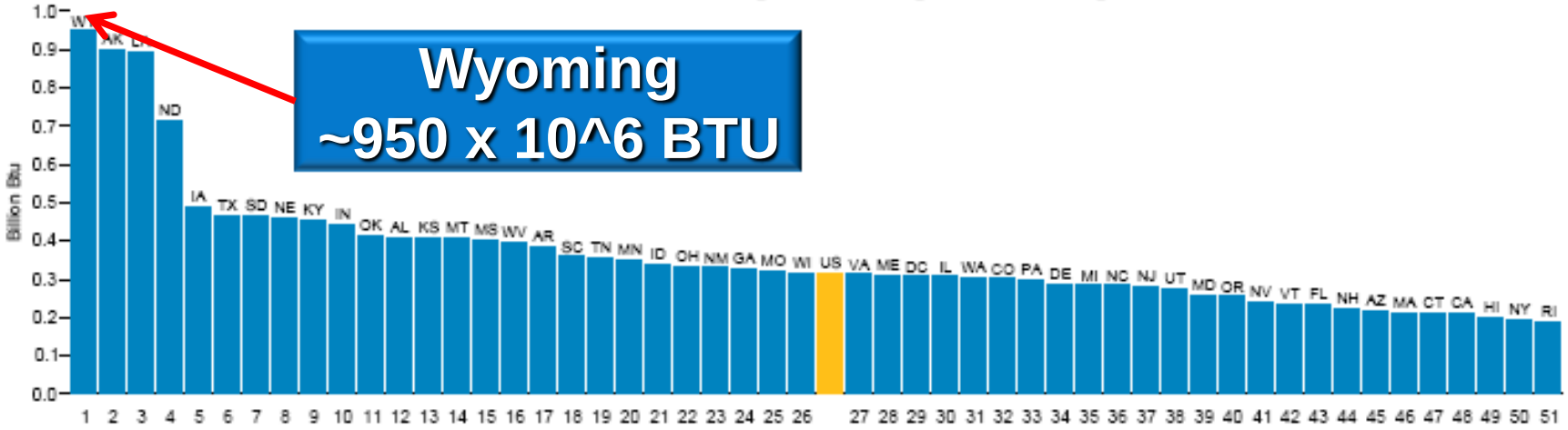


Source: U.S. Energy Information Administration / Annual Energy Review 2011

Estimated State-Level Energy Consumption-2010

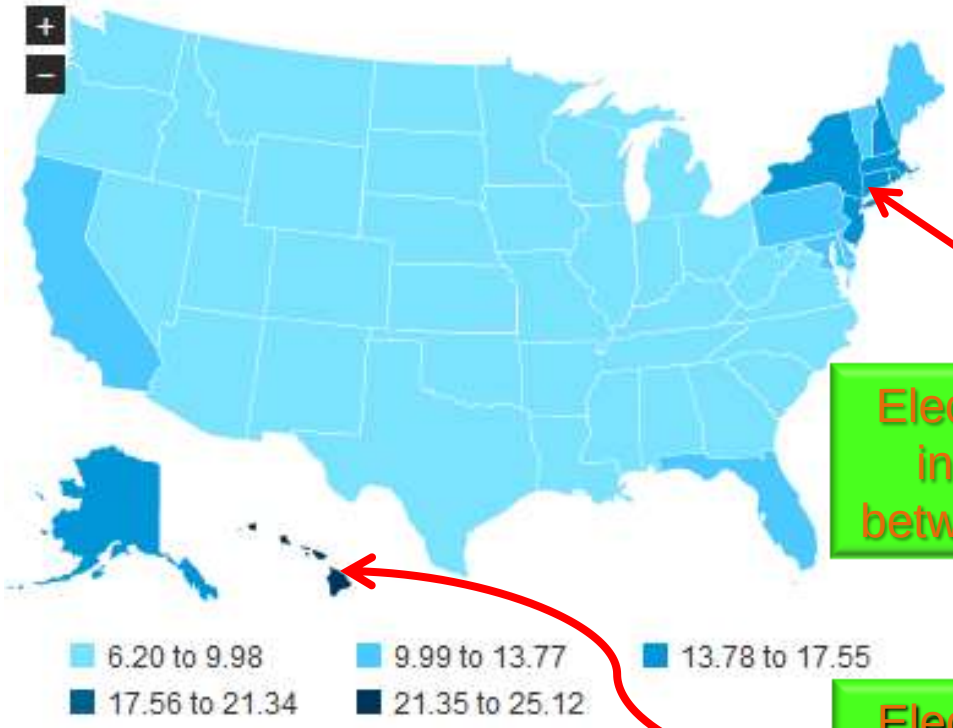


Estimated Consumption per Capita-2010



Source: U.S. Energy Information Administration / Annual Energy Review 2011

U.S. Average Retail Price of Electricity-2010 ($0.0983/kWh)

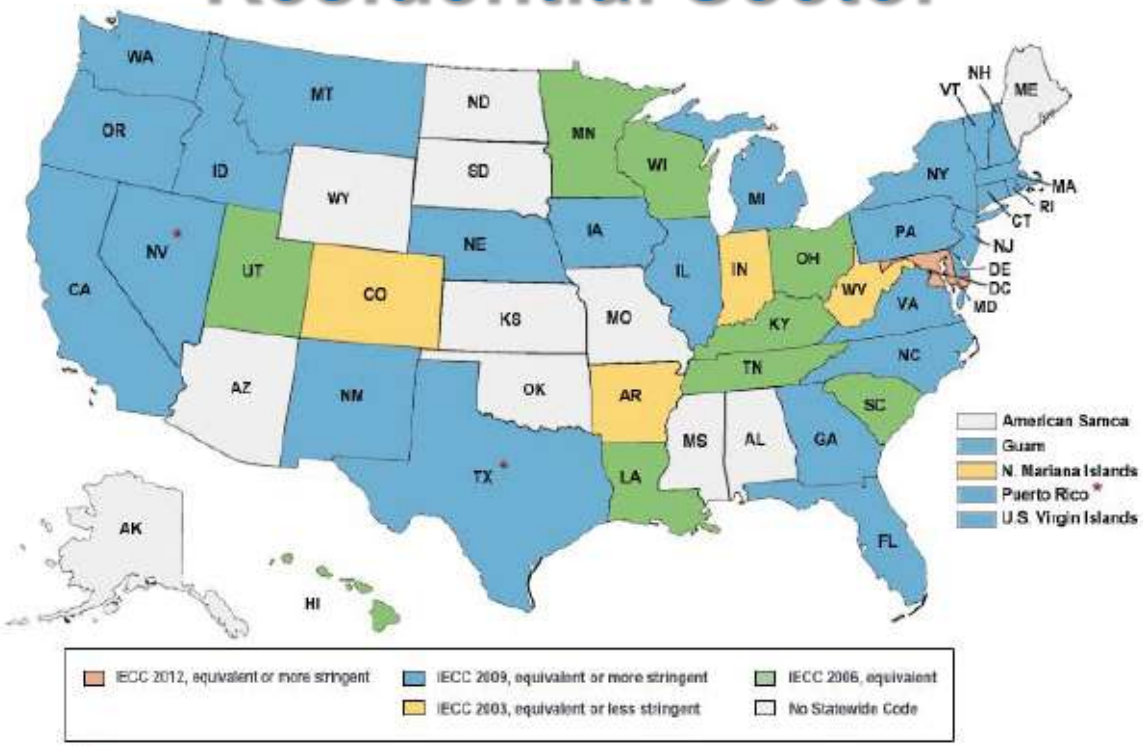


Electricity Cost per kWh in this part of U.S. is between $0.18 and $0.21

Electricity Cost per kWh in this part of U.S. is between $0.21 and $0.25

Source: U.S. Energy Information Administration - 2010

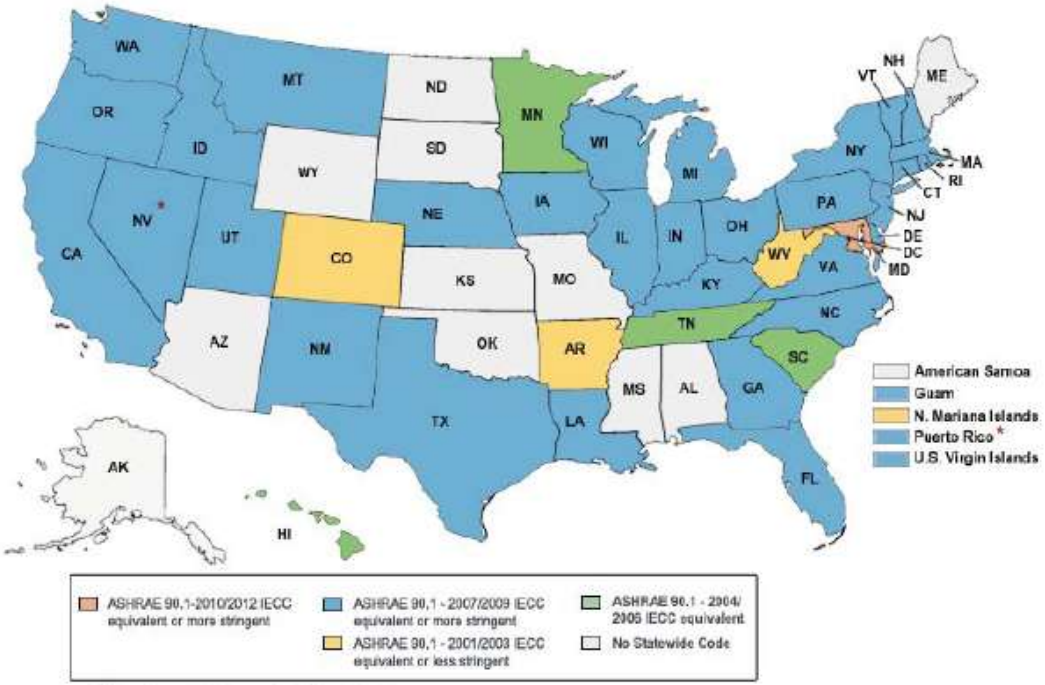
The Status of State Energy Codes Residential Sector



- **States like DE and MD are already using IECC 2012 equivalent or more stringent Energy Code.**

Source: U.S. DOE/EERE, http://www.energycodes.gov/states

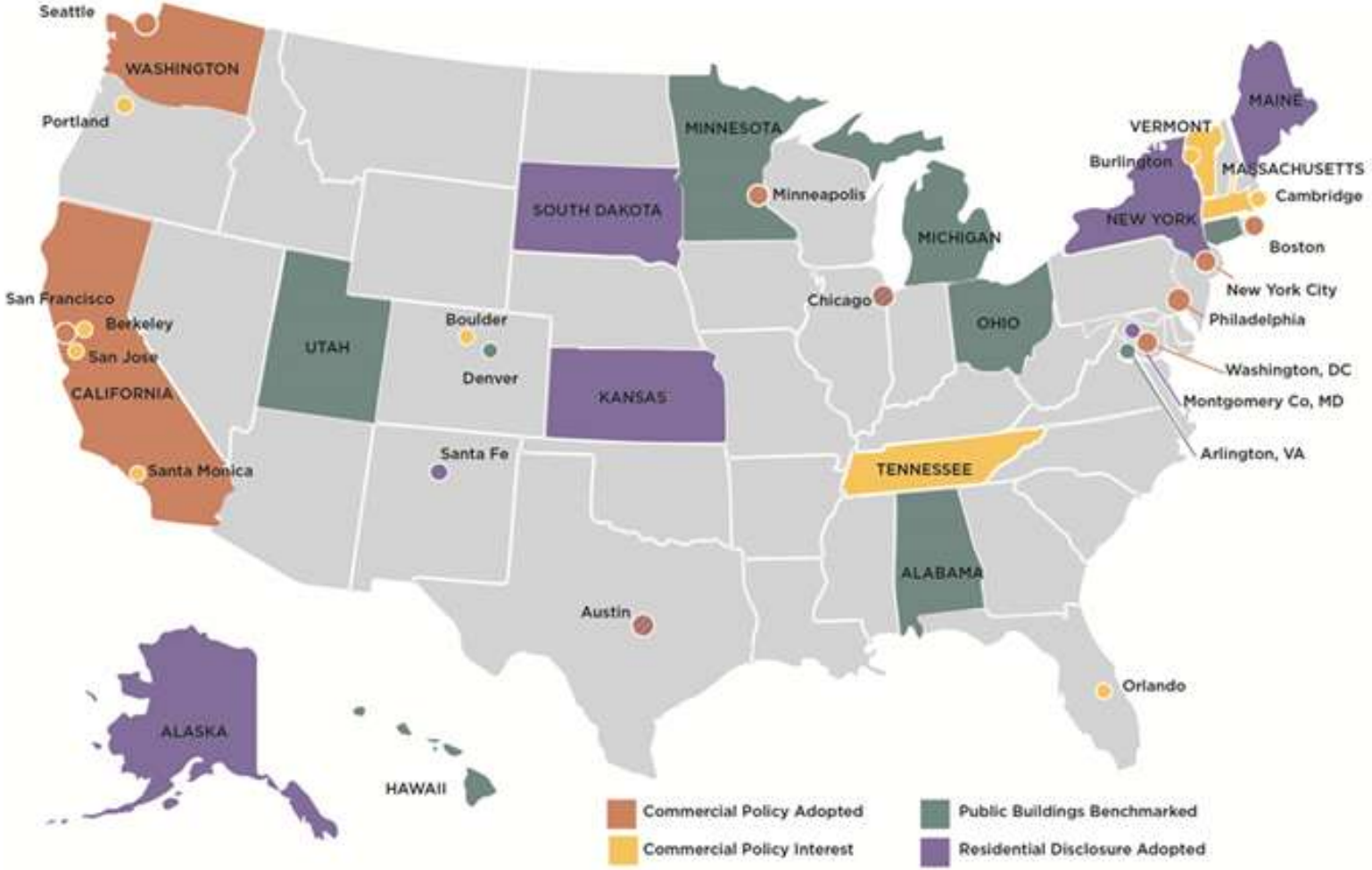
The Status of State Energy Codes Commercial Sector



- **States like DE and MD are already using ASHRAE 90.1-2010 / IECC 2012 equivalent or more stringent Energy Code.**

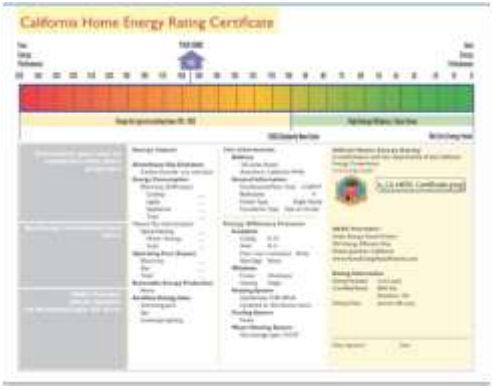
Source: U.S. DOE/EERE, http://www.energycodes.gov/states

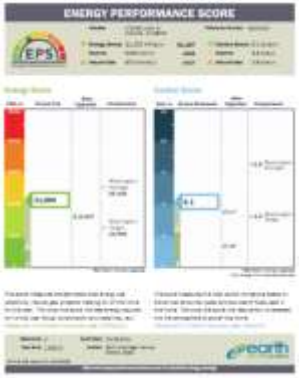
U.S. Building Energy Rating and Disclosure Policies

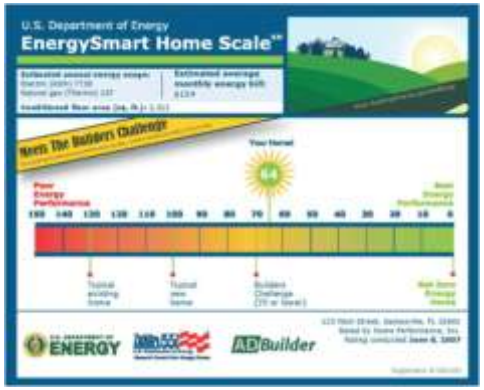


Source: http://www.buildingrating.org/content/us-policy-briefs

Energy Labels, Certificates, and Scorecards currently in use or development in U.S.A

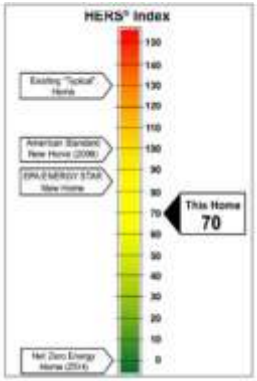


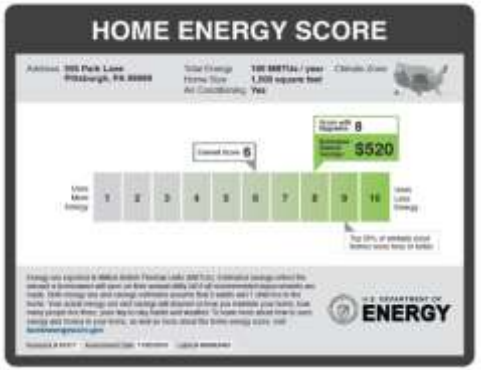




Source: http://www.buildingrating.org/content/us-policy-briefs

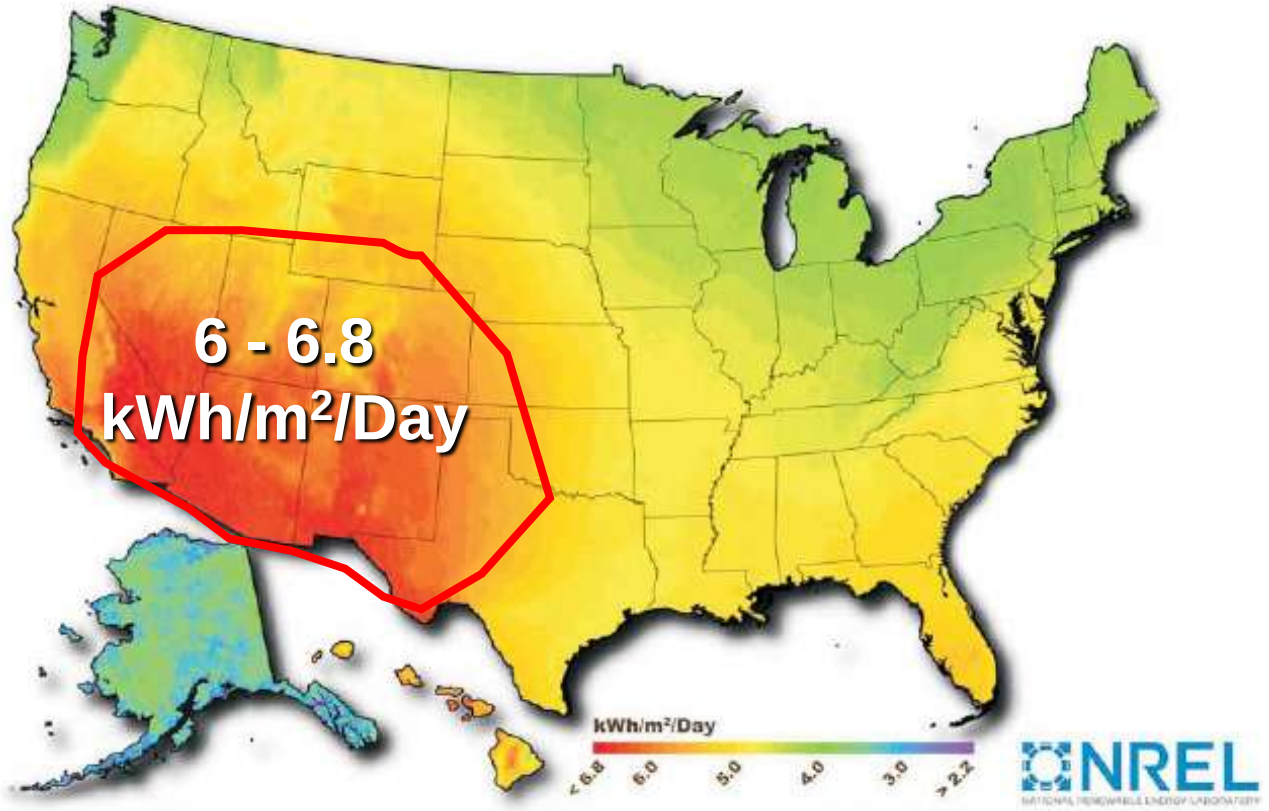
Energy Labels, Certificates, and Scorecards currently in use or development in U.S.A (Cont…)





Source: http://www.buildingrating.org/content/us-policy-briefs

U.S. Solar Resources



- **Most U.S states have an average of 5 kWh/m²/Day**

Source: U.S. Energy Information Administration / Annual Energy Review 2011

Solar Collectors in Operation by Country

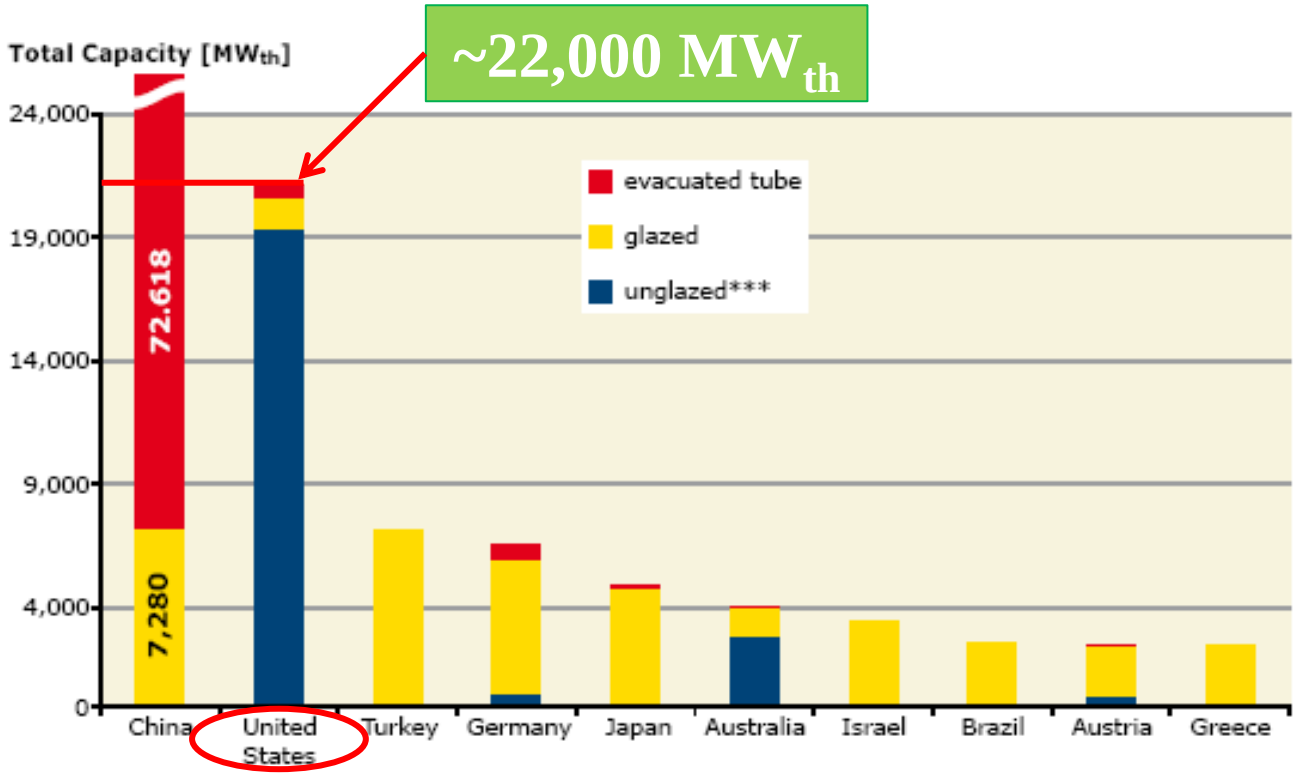
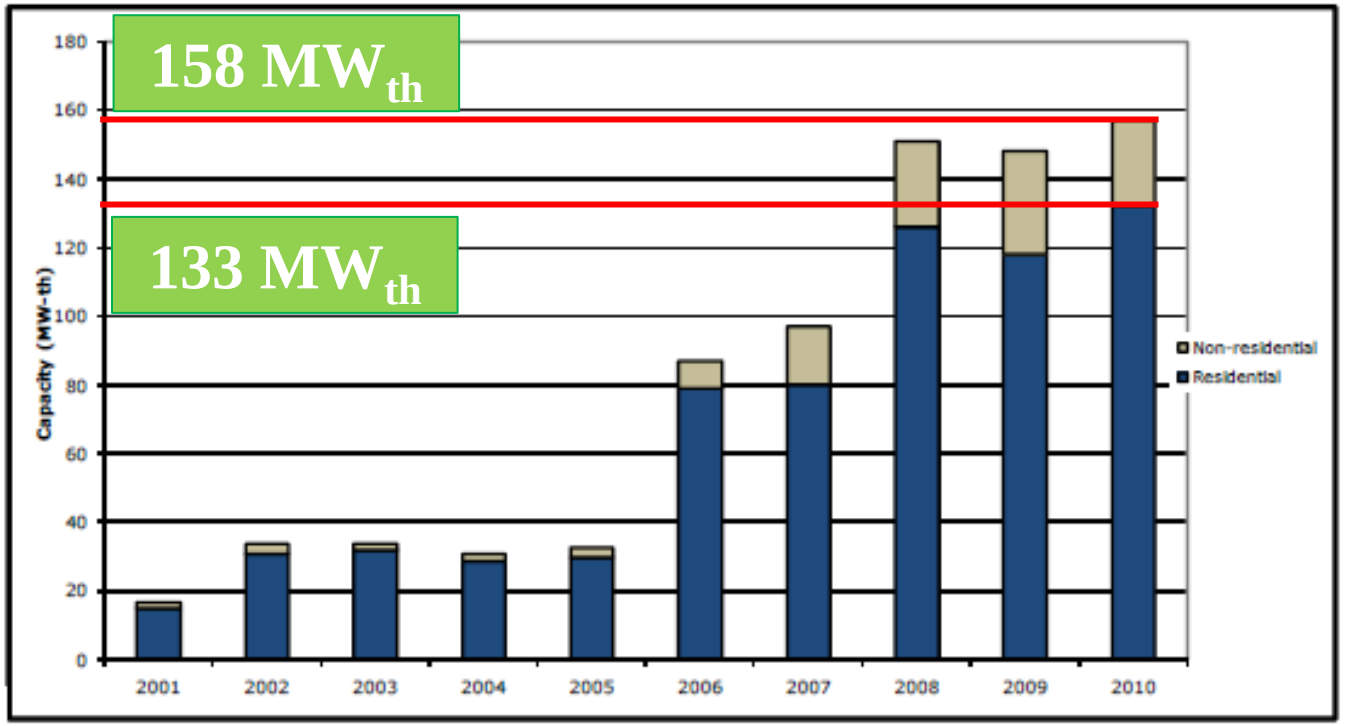


Figure 4: Total capacity in operation of water collectors of the 10 leading countries at the end of 2007

Source: Solar Heating & Cooling Worldwide – 2010 Edition

Annual Installed U.S. Capacity for SHC

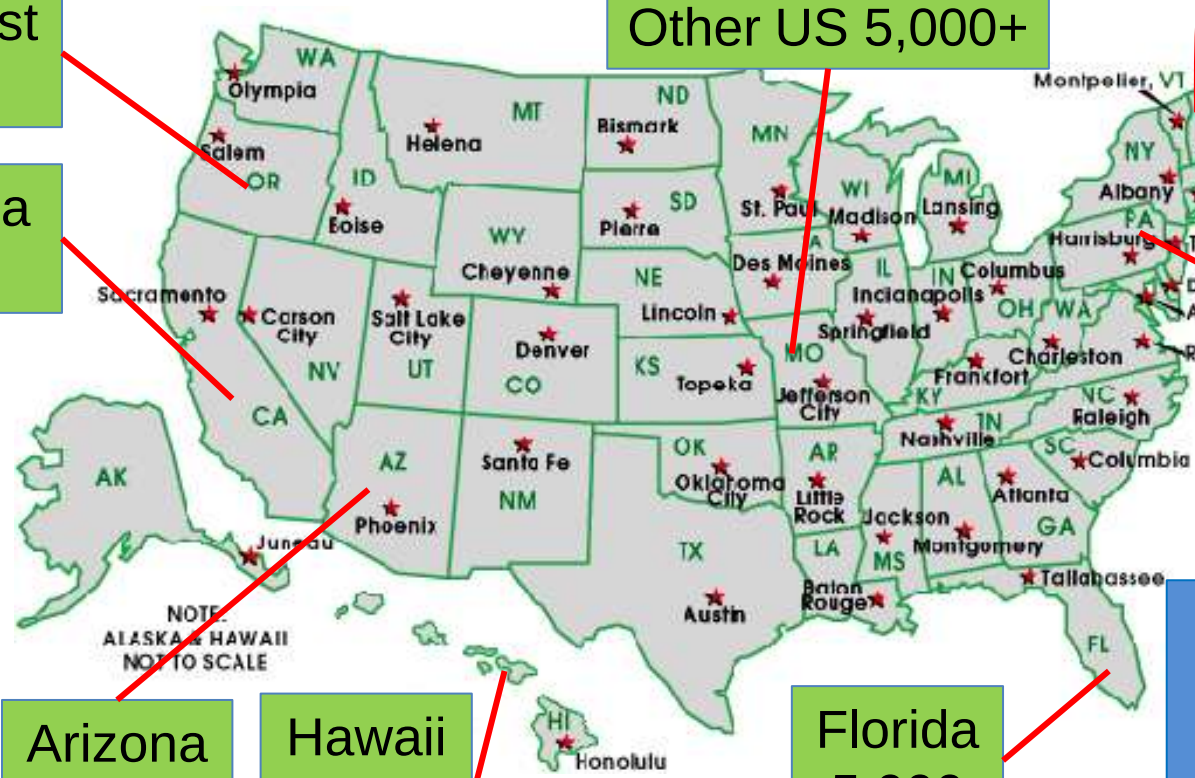


Based on analysis of collector shipment data from EIA and GTM/SEIA.

Source: U.S. Solar Market Trends 2010 / June 2011

- **84% of these installations are in the residential sector**

Estimated US Solar Thermal Installations-2009



Northwest 500

California 1,000

Midwest and All Other US 5,000+

New England + New York 3,000

Mid-Atlantic 1,500

Arizona 1,500

Hawaii Islands 8,750

Florida 5,000

Total ~26,250 Installations, each 64 sf. (1,680,000 sf)

Current Trends

Solar Water Heating

- Evacuated Tube Collectors are getting increased popularity

Solar Swimming Pool Heating

- More and more systems are installed with an average of 350-400 ft^2/system

Solar Space Heating

- Interest on combined heating and hot water systems (Combi-Systems) is growing

Solar Air Conditioning

- SAC is gaining interest especially in geographical regions with generous incentives, and high energy cost

Solar Rating and Certification Corporation

- SRCC is a Non-profit organization established in 1980
- OG-100: Solar Collectors
- OG-300: Solar Water Heating Systems
- 110 SRCC Participants

SRCC Certified Solar Collectors as 2012

- 946 Glazed (OG-100)
- 43 Unglazed (OG-100)
- 4 Concentrating (OG-100)
- 20 Integral Collector Storage (ISC) and Non-Separable Thermosiphon Collector (OG-100)
- 2,115 Certified Systems (OG-300)

Typical Solar Collector Certification & Rating

SOLAR COLLECTOR CERTIFICATION AND RATING

SRCC OG-100

CERTIFIED SOLAR COLLECTOR

SUPPLIER:	Viessmann Manufacturing Company (US) Inc. 45 Access Road Warwick, RI 02886 USA
MODEL:	Vitosol 100-F, SV1/SH1
COLLECTOR TYPE:	Glazed Flat-Plate
CERTIFICATION#:	2007042A
Original Certification Date:	19-NOV-08

COLLECTOR THERMAL PERFORMANCE RATING

Kilowatt-hours Per Panel Per Day				Thousands of BTU Per Panel Per Day			
CATEGORY (Ti-Ta)	CLEAR DAY (6.3 kWh / m² day)	MILDLY CLOUDY (4.7 kWh / m² day)	CLOUDY DAY (3.1 kWh / m² day)	CATEGORY (Ti-Ta)	CLEAR DAY (2000 Btu / ft² day)	MILDLY CLOUDY (1500 Btu / ft² day)	CLOUDY DAY (1000 Btu / ft² day)
A (-5 °C)	11.3	8.5	5.8	A (-9 °F)	38.6	29.1	19.7
B (5 °C)	10.3	7.5	4.8	B (9 °F)	35.2	25.7	16.3
C (20 °C)	8.8	6.0	3.3	C (36 °F)	30.0	20.6	11.4
D (50 °C)	5.8	3.3	1.0	D (90 °F)	19.7	11.2	3.3
E (80 °C)	3.0	0.9	0.0	E (144 °F)	10.1	3.1	0.0

A- Pool Heating (Warm Climate) **B**- Pool Heating (Cool Climate) **C**- Water Heating (Warm Climate) **D**- Water Heating (Cool Climate) **E**- Air Conditioning

COLLECTOR SPECIFICATIONS

Gross Area:	2.494 m²	26.84 ft²	Net Aperture Area:	2.34 m² 25.13 ft²
Dry Weight:	42.2 kg	93 lb	Fluid Capacity:	1.7 liter 0.4 gal
Test Pressure:	1103. KPa	160. psig		

COLLECTOR MATERIALS

Frame:	Aluminum
Cover (Outer):	Low Iron Tempered Glass
Cover (Inner):	None

Pressure Drop

Flow		ΔP	
ml/s	gpm	Pa	in H_2O
20.00	0.32	9846.00	39.57
50.00	0.79	36448.0	146.5
80.00	1.27	77248.00	310.46

Absorber Material:	Tube - Copper / Plate - Copper Sheet	Insulation Side:	None
Absorber Coating:	Black Chrome	Insulation Back:	Mineral Fibre

TECHNICAL INFORMATION

Efficiency Equation [NOTE: Based on gross area and (P)=Ti-Ta]

				Y INTERCEPT	SLOPE
SI Units:	η= 0.769	-3.61400 (P)/I	-0.01358 $(P)^2/I$	0.776	-4.427 $W/m^2 °C$
IP Units:	η= 0.769	-0.63661 (P)/I	-0.00133 $(P)^2/I$	0.776	-0.780 $Btu/hr.ft^2 °F$

Incident Angle Modifier [(S)=1/cosθ - 1, 0°<θ<=60°]

Kτα = 1	-0.100 (S)	-0.215 $(S)^2$	Test Fluid: Water
Kτα = 1	-0.32 (S)	Linear Fit	Test Flow Rate: 20.0 ml /s.m^2 0.0295 gpm/ft^2

REMARKS:

March, 2012
Certification must be renewed annually. For current status contact:
SOLAR RATING & CERTIFICATION CORPORATION
400 High Point Drive, Suite 400 • Cocoa, Florida 32926 • (321) 213-6037 • Fax (321) 821-0910

SOLAR COLLECTOR CERTIFICATION AND RATING

SRCC OG-100

CERTIFIED SOLAR COLLECTOR

SUPPLIER:	Viessmann Manufacturing Company (US) Inc. 45 Access Road Warwick, RI 02886 USA
MODEL:	Vitosol 300-T, SP3 /3m2
COLLECTOR TYPE:	Tubular
CERTIFICATION#:	2009020B
Original Certification Date:	09-AUG-06

COLLECTOR THERMAL PERFORMANCE RATING

Kilowatt-hours Per Panel Per Day				Thousands of BTU Per Panel Per Day			
CATEGORY (Ti-Ta)	CLEAR DAY (6.3 kWh / m² day)	MILDLY CLOUDY (4.7 kWh / m² day)	CLOUDY DAY (3.1 kWh / m² day)	CATEGORY (Ti-Ta)	CLEAR DAY (2000 Btu / ft² day)	MILDLY CLOUDY (1500 Btu / ft² day)	CLOUDY DAY (1000 Btu / ft² day)
A (-5 °C)	12.7	9.5	6.4	A (-9 °F)	43.2	32.5	21.9
B (5 °C)	12.2	9.1	6.0	B (9 °F)	41.7	31.1	20.4
C (20 °C)	11.5	8.4	5.3	C (36 °F)	39.3	28.7	18.0
D (50 °C)	10.1	7.0	3.9	D (90 °F)	34.6	24.0	13.5
E (80 °C)	8.6	5.5	2.7	E (144 °F)	29.5	18.9	9.1

A- Pool Heating (Warm Climate) **B**- Pool Heating (Cool Climate) **C**- Water Heating (Warm Climate) **D**- Water Heating (Cool Climate) **E**- Air Conditioning

COLLECTOR SPECIFICATIONS

Gross Area:	4.287 m²	46.15 ft²	Net Aperture Area:	3.29 m² 35.36 ft²
Dry Weight:	68.0 kg	150. lb	Fluid Capacity:	1.8 liter 0.5 gal
Test Pressure:	130. KPa	19. psig		

COLLECTOR MATERIALS

Frame:	Aluminum
Cover (Outer):	Glass Vacuum Tube
Cover (Inner):	None

Pressure Drop

Flow		ΔP	
ml/s	gpm	Pa	in H_2O

Absorber Material:	Tube - Copper / Plate - Copper fin	Insulation Side:	Vacuum
Absorber Coating:	Sputtered cermet	Insulation Back:	Vacuum

TECHNICAL INFORMATION

Efficiency Equation [NOTE: Based on gross area and (P)=Ti-Ta]

				Y INTERCEPT	SLOPE
SI Units:	η= 0.508	-0.91560 (P)/I	-0.00300 $(P)^2/I$	0.509	-1.095 $W/m^2 °C$
IP Units:	η= 0.508	-0.16128 (P)/I	-0.00029 $(P)^2/I$	0.509	-0.193 $Btu/hr.ft^2 °F$

Incident Angle Modifier [(S)=1/cosθ - 1, 0°<θ<=60°]

Kτα = 1	0.519 (S)	-0.743 $(S)^2$	Test Fluid: Propylene Glycol & Water
Kτα = 1	-0.26 (S)	Linear Fit	Test Flow Rate: 20.5 ml /s.m^2 0.0302 gpm/ft^2

REMARKS: Collector tested with long axis of tubes oriented north-south. IAM perpendicular to the tubes is listed above. IAM parallel to the tubes = 1.0 - 0.31(S)

March, 2012
Certification must be renewed annually. For current status contact:
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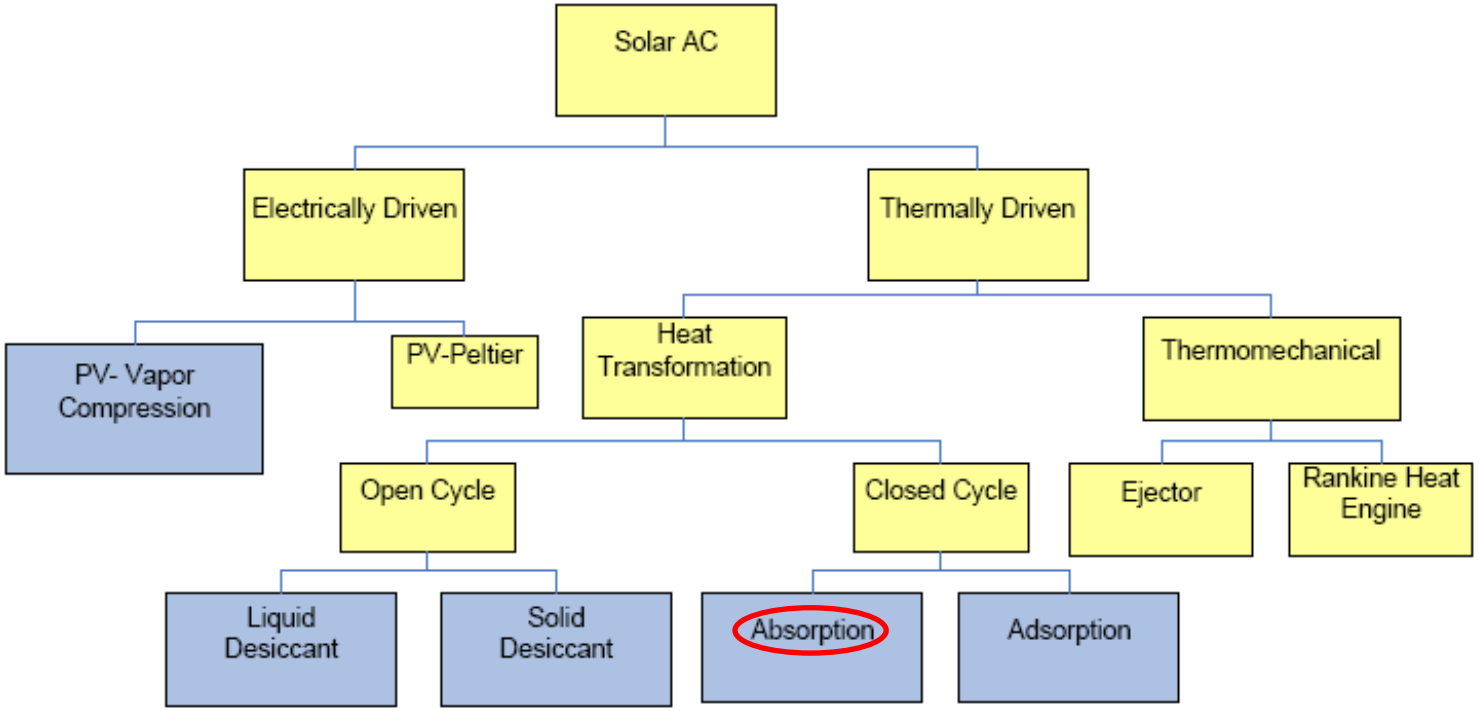
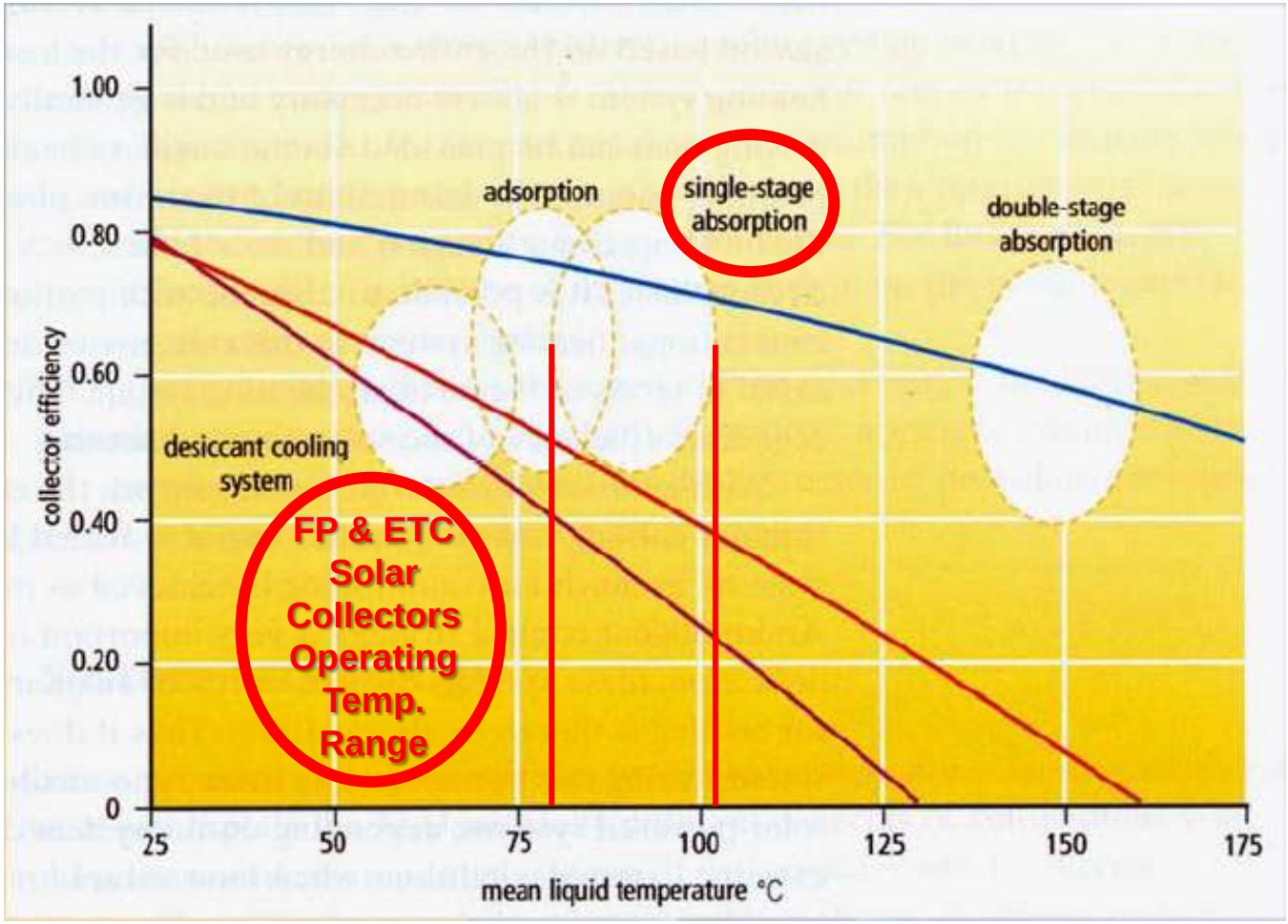
400 High Point Drive, Suite 400 • Cocoa, Florida 32926 • (321) 213-6037 • Fax (321) 821-0910

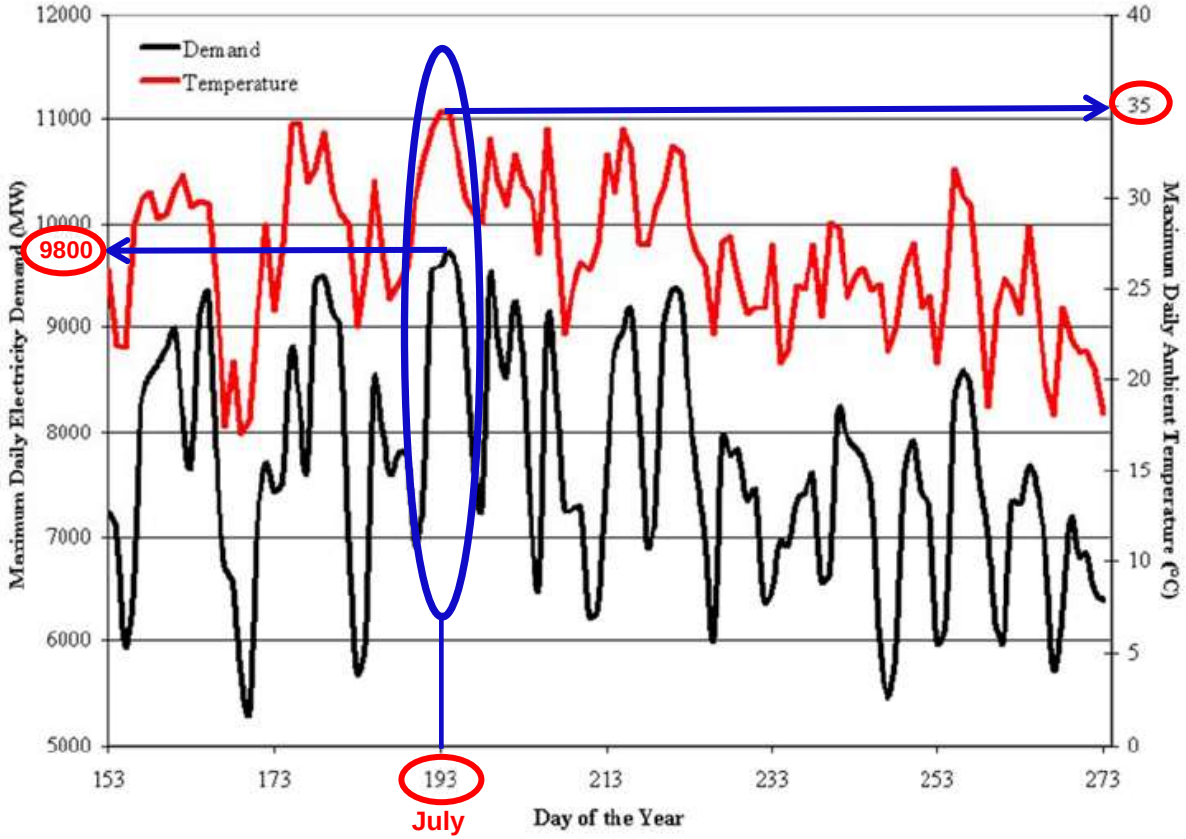
Solar Air-Conditioning Types



Solar Air-Conditioning Types (Cont…)

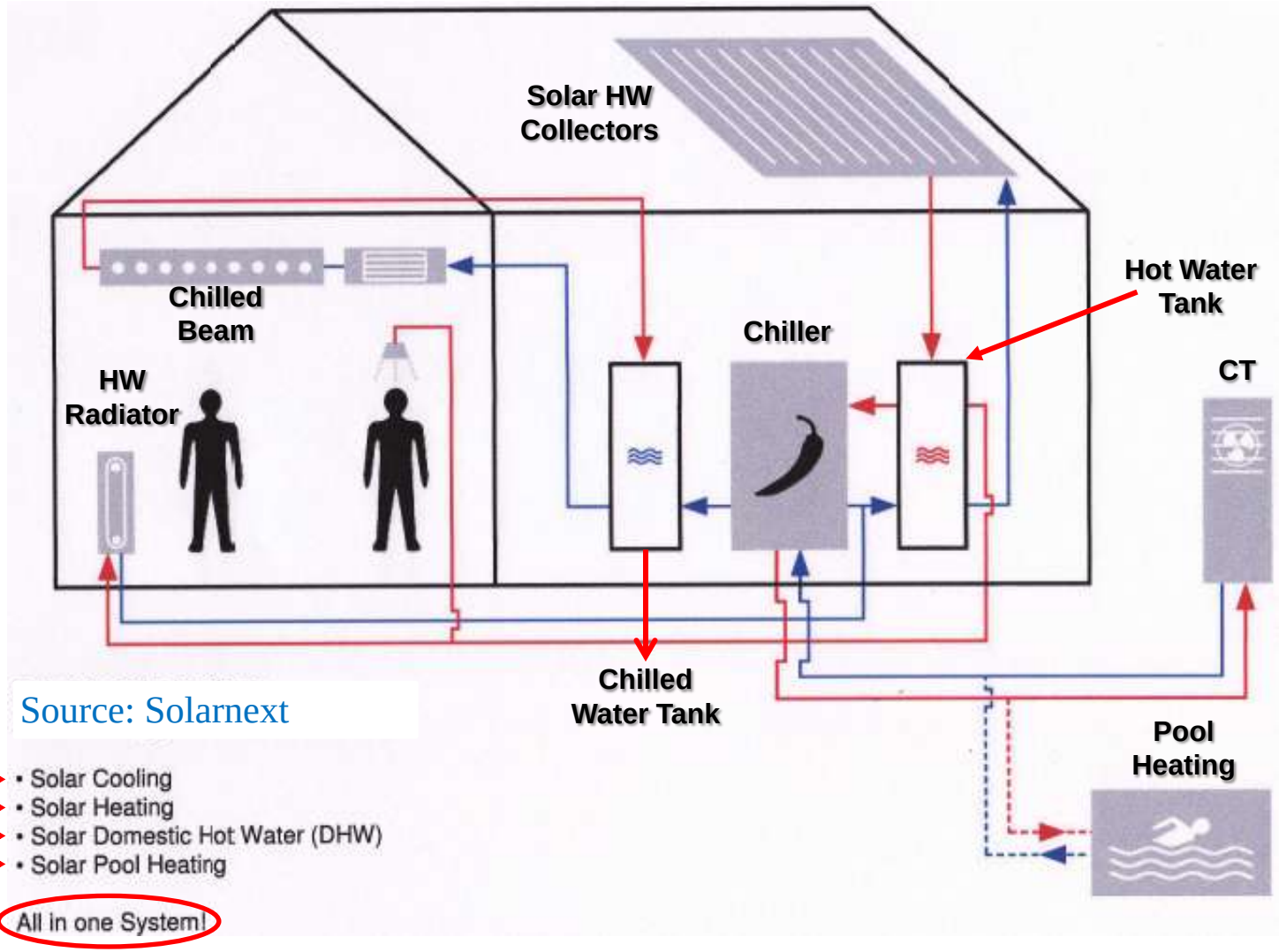


Why Solar Cooling Makes Sense!



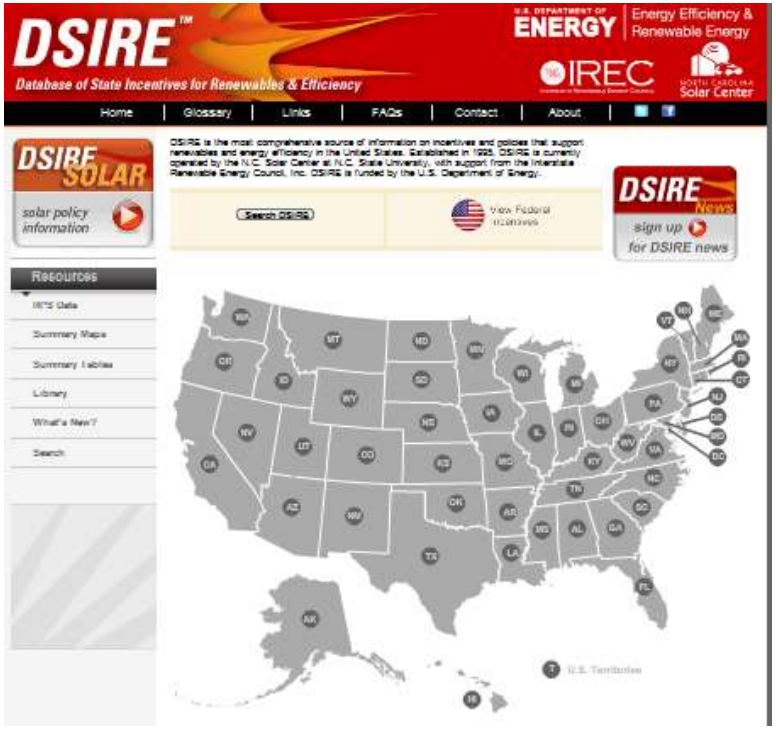
- Look at the correlation between Hi. Temp. & Hi. demand. The higher the temperature the higher the demand

Application of SAC in Buildings



Source: Solarnext

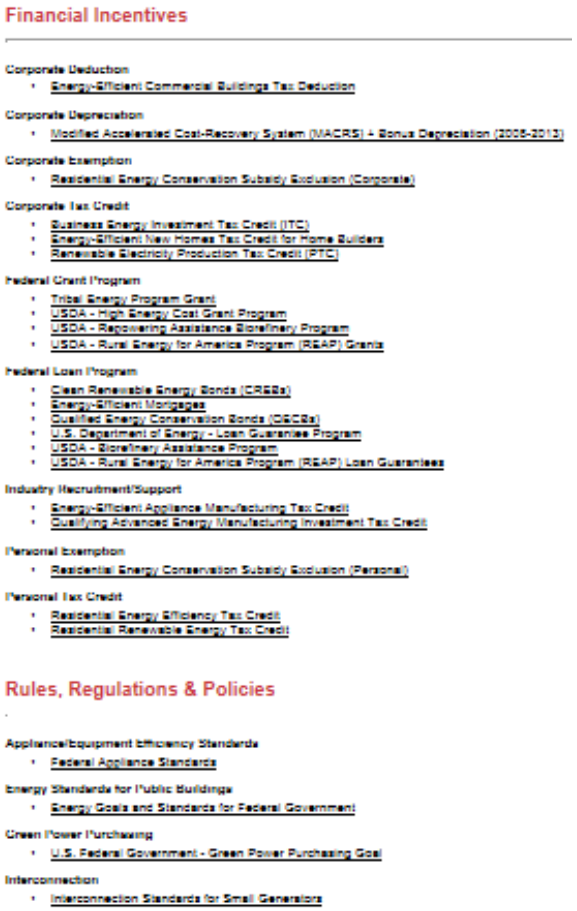
Database of State Incentives for Renewables & Efficiency



- There are several incentive programs that are available at Federal, State and local levels which can assist you reduce the first cost of your next project.

Source: http://www.dsireusa.org/

Federal Incentives / Policies for Renewables & Efficiency



Financial Incentives

Corporate Deduction
- Energy-Efficient Commercial Buildings Tax Deduction

Corporate Depreciation
- Modified Accelerated Cost-Recovery System (MACRS) + Bonus Depreciation (2008-2013)

Corporate Exemption
- Residential Energy Conservation Subsidy Exclusion (Corporate)

Corporate Tax Credit
- Business Energy Investment Tax Credit (ITC)
- Energy-Efficient New Homes Tax Credit for Home Builders
- Renewable Electricity Production Tax Credit (PTC)

Federal Grant Program
- Tribal Energy Program Grant
- USDA - High Energy Cost Grant Program
- USDA - Repowering Assistance Biorefinery Program
- USDA - Rural Energy for America Program (REAP) Grants

Federal Loan Program
- Clean Renewable Energy Bonds (CREBs)
- Energy-Efficient Mortgages
- Qualified Energy Conservation Bonds (QECBs)
- U.S. Department of Energy - Loan Guarantee Program
- USDA - Biorefinery Assistance Program
- USDA - Rural Energy for America Program (REAP) Loan Guarantees

Industry Recruitment/Support
- Energy-Efficient Appliance Manufacturing Tax Credit
- Qualifying Advanced Energy Manufacturing Investment Tax Credit

Personal Exemption
- Residential Energy Conservation Subsidy Exclusion (Personal)

Personal Tax Credit
- Residential Energy Efficiency Tax Credit
- Residential Renewable Energy Tax Credit

Rules, Regulations & Policies

Appliance/Equipment Efficiency Standards
- Federal Appliance Standards

Energy Standards for Public Buildings
- Energy Goals and Standards for Federal Government

Green Power Purchasing
- U.S. Federal Government - Green Power Purchasing Goal

Interconnection
- Interconnection Standards for Small Generators

Source: http://www.dsireusa.org/incentives/index.cfm?state=us

California Solar Initiative-Solar Thermal Program

Program Overview:	
State:	California
Incentive Type:	State Rebate Program
Eligible Renewable/Other Technologies:	Solar Water Heat, Solar Space Heat, Solar Thermal Process Heat, Solar-assisted absorption chillers, (only non-residential solar pool heating), Solar Pool Heating
Applicable Sectors:	Commercial, Industrial, Residential, Nonprofit, Schools, Local Government, State Government, Fed. Government, Multi-Family Residential, Low-Income Residential
Amount:	*Step 1 Incentive Rates (contact utility to determine current incentive levels):* **Single Family Residential Incentives:** Systems that displace natural gas: $18.59 per estimated therm displaced Systems that displace electricity or propane: $0.54 per estimated kWh displaced **Commercial/Multifamily Incentives:** Systems that displace natural gas: $14.53 per estimated therm displaced Systems that displace electricity or propane: $0.42 per estimated kWh displaced **Single-Family Low-Income Incentives:** Systems that displace natural gas: $25.64 per estimated therm displaced **Multifamily Low-Income Incentives:** Systems that displace natural gas: $19.23 per estimated therm displaced
Maximum Incentive:	*Step 1 Incentive Limits (contact utility to determine current incentive limits):* Single-family residential systems that displace natural gas: $2,719 Single-family residential systems that displace electricity or propane: $1,834 Commercial and multifamily residential systems that displace natural gas: $500,000 Commercial and multifamily residential systems that displace electricity or propane: $250,000
Equipment Requirements:	Residential systems must be certified to SRCC OG-300 by either SRCC or International Association of Plumbing and Mechanical Officials (IAPMO) Solar collectors used in eligible commercial systems must be certified to SRCC OG-100 by either SRCC or IAPMO Only non-residential solar pool heaters are eligible.
Installation Requirements:	Systems must be installed by an appropriately licensed contractor who is listed as being eligible to participate in the program. Self-installations are permitted if the building owner attends a designated CSI-Thermal Program training workshop.

Source: http://dsireusa.org/incentives/incentive.cfm?Incentive_Code=CA214F&re=0&ee=0

Thank You For Listening

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