SIMULATED PERFORMANCE OF SOLAR DOMESTIC HOT WATER TECHNOLOGIES IN NEW YORK STATE

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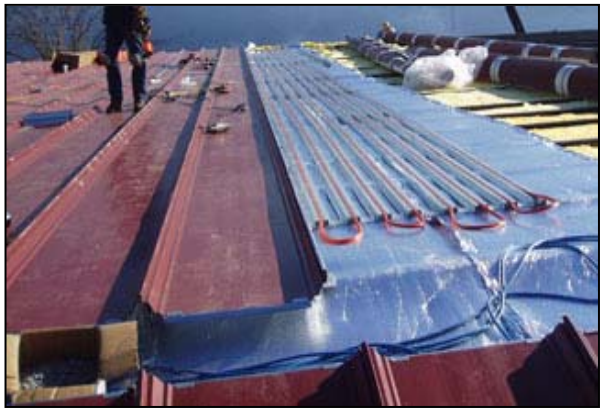
National Context

- 2006: 20 million ft^2 (2 million m^2) of solar thermal collectors shipped in US
- Top 5 States: FL, CA, NV, AZ, NY
- NY = 3% of national market
- New York is coldest, most northerly state on the list
- NY has a diverse climate
  - NY City & Long Island = mild, coastal
  - Buffalo = cold, near great lakes
  - Lake Placid = cold, mountainous, inland

Methodology & Scope

Flat Plate

Evacuated Tube



Building Integrated

- Solar thermal technology converts sun's radiation into useful heat
- Analyzed systems are available on the market today
- Manufacturers & installers were asked to specify complete, cost-effective systems

Abstract

This study:

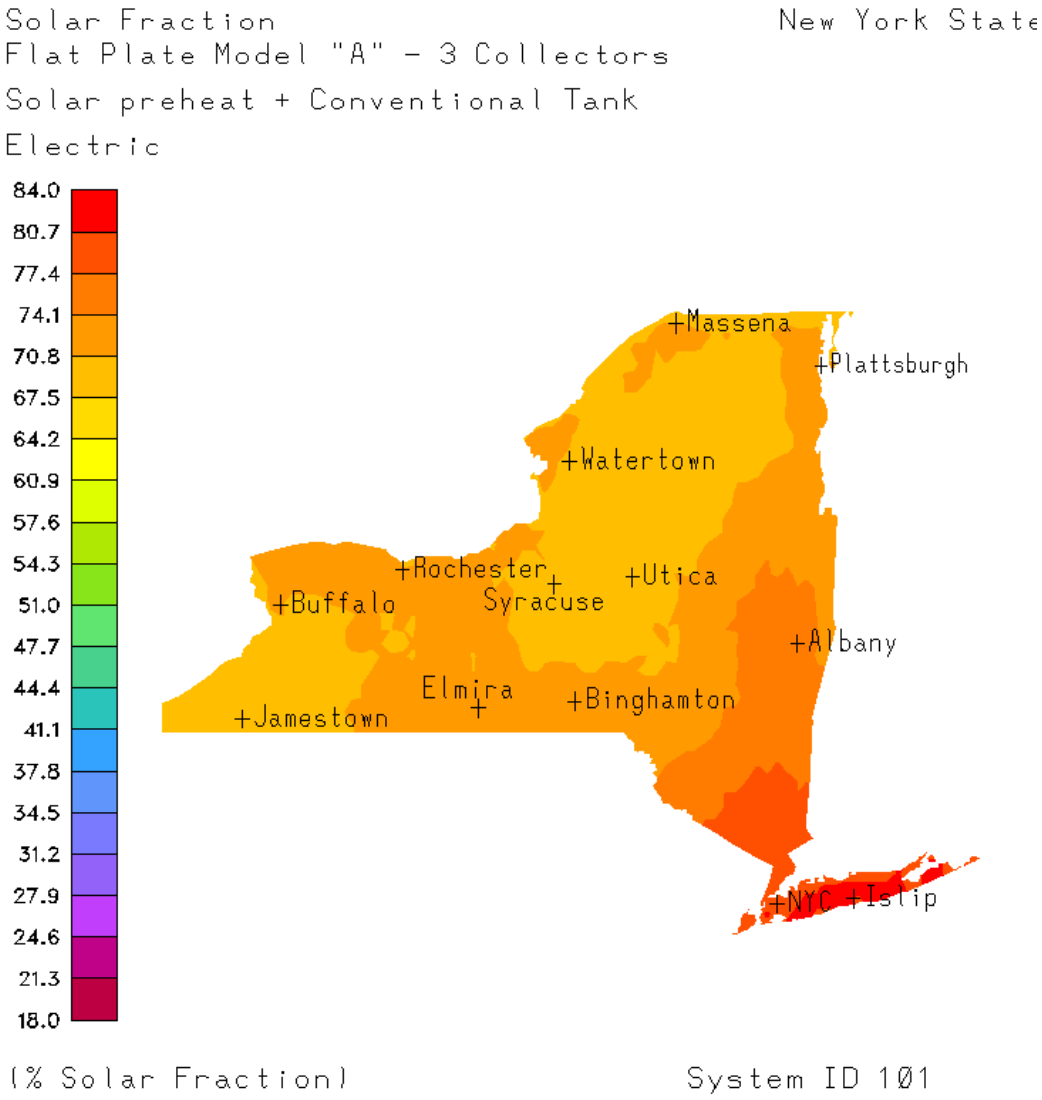
- Utilizes TRNSYS computer simulations
- Compares the simulated performance of Solar Domestic Hot Water and Baseline DHW systems on single family homes
- Explores 13 regions of New York State, and
- 3 solar collector technologies
  - Flat Plate
  - Evacuated Tube
  - Building Integrated

Abstract

- Solar Domestic Hot Water (SDHW) system performance evaluated in terms of:
  - Energy Production
  - Solar Fraction

Abstract

- Results
  - Geographiclal renderings
  - Different colors represent different values of solar fraction for the selected system



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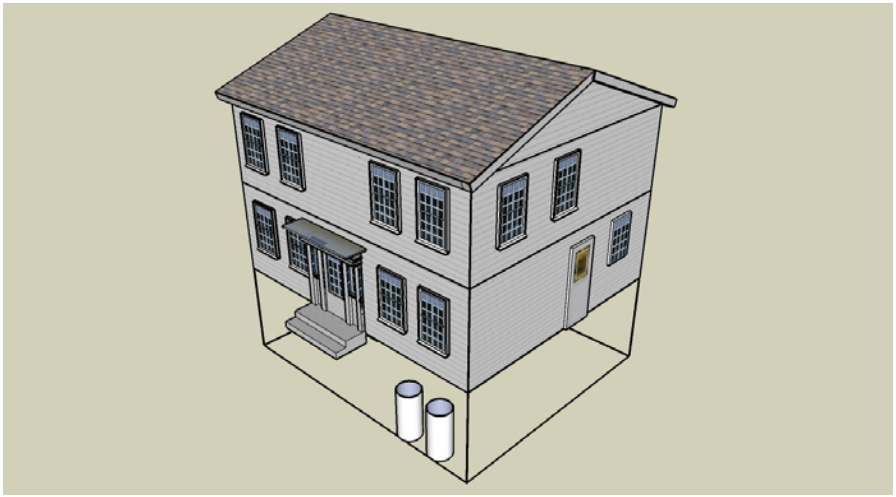
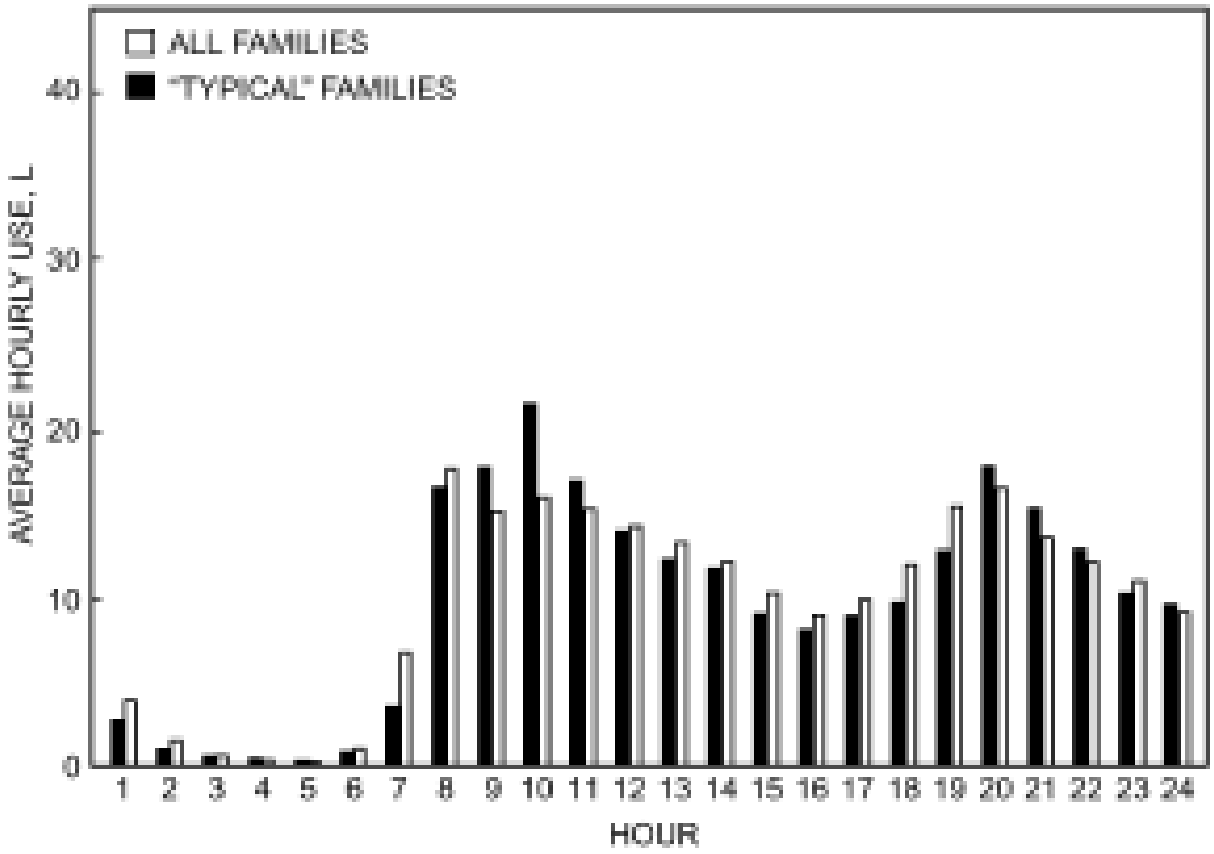
Model New York State Home

- Every analyzed system is capable of providing reliable heated water to a typical family of four in NYS
  - Four occupants
  - Basement & Attic
  - Two Stories
  - Sloped Roof pitched 30 degrees toward South



Hot Water Consumption

- Typical family usage (ASHRAE 2003)



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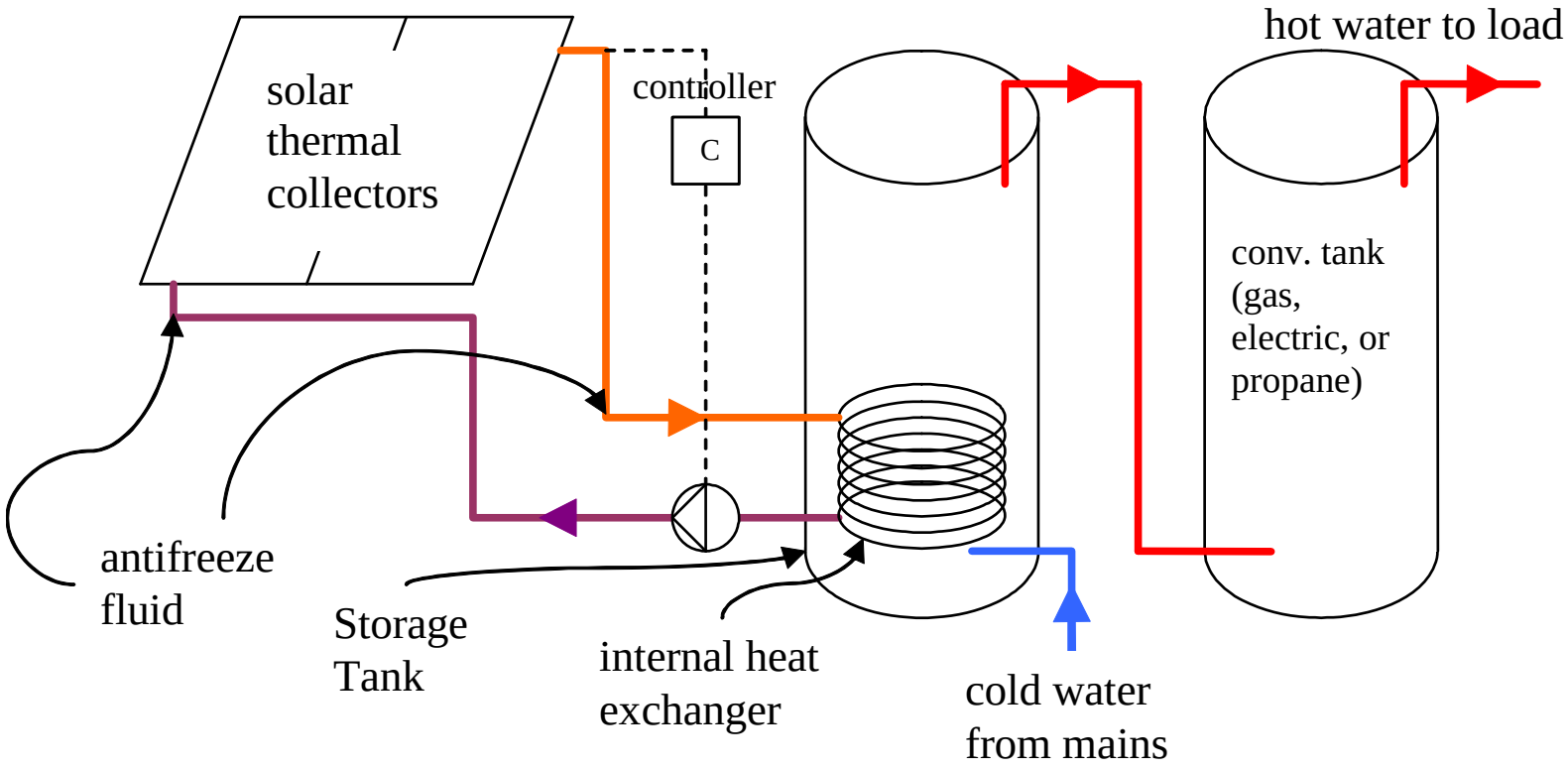
SDHW System Design Factors

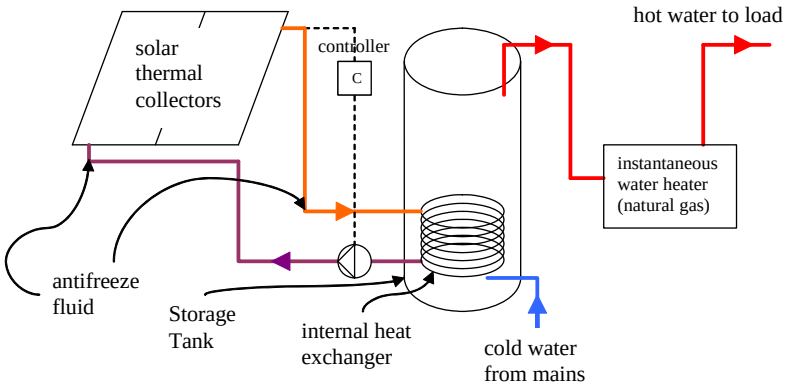
Sys. ID	Collector Type	Net Aperture Area (m^2)	Delta T (off/on) (°C)	Pumping Rate (L/s)
1xx	Flat A	6.42	11.1/13.3	0.095
2xx	Evac A	5.43	10.3/14.7	0.095
3xx	Evac B	5.45	10.3/14.7	0.095
5xx	Flat B	4.59	7.8/15	0.095
6xx	Evac C	3.75	10.3/14.7	0.095
7xx	Bldg Int	55.74	11.1/---	0.158
Sys. ID	**Collector Low Limit (°C)**	**Tank High Limit (°C)**	**Tank 1 Volume (gal)**	**Tank 1 Volume (L)**
1xx	N/A	76.7	105	398
2xx	N/A	79.4	105	398
3xx	N/A	79.4	80	303
5xx	26.7	71.1	80	303
6xx	N/A	79.4	80	303
7xx	N/A	N/A	80	303

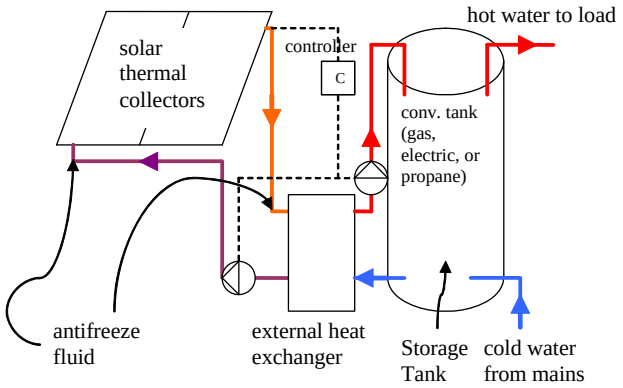
SDHW Tank Designs

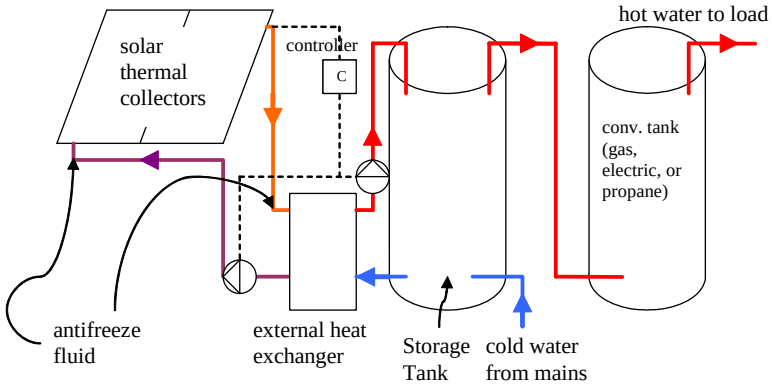


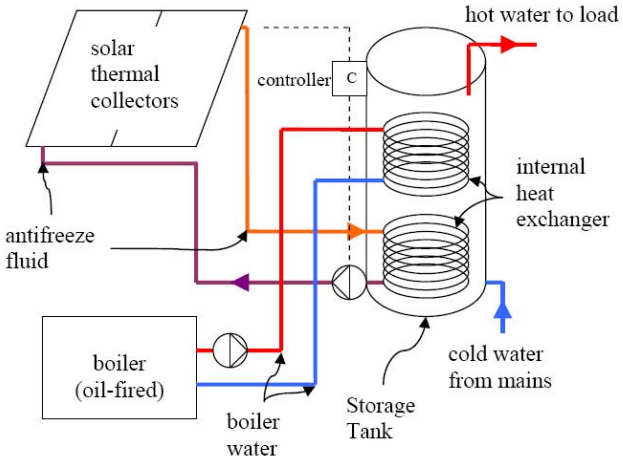
Tank Design x0x
Solar preheat tank + Conventional tank

SDHW Tank Designs









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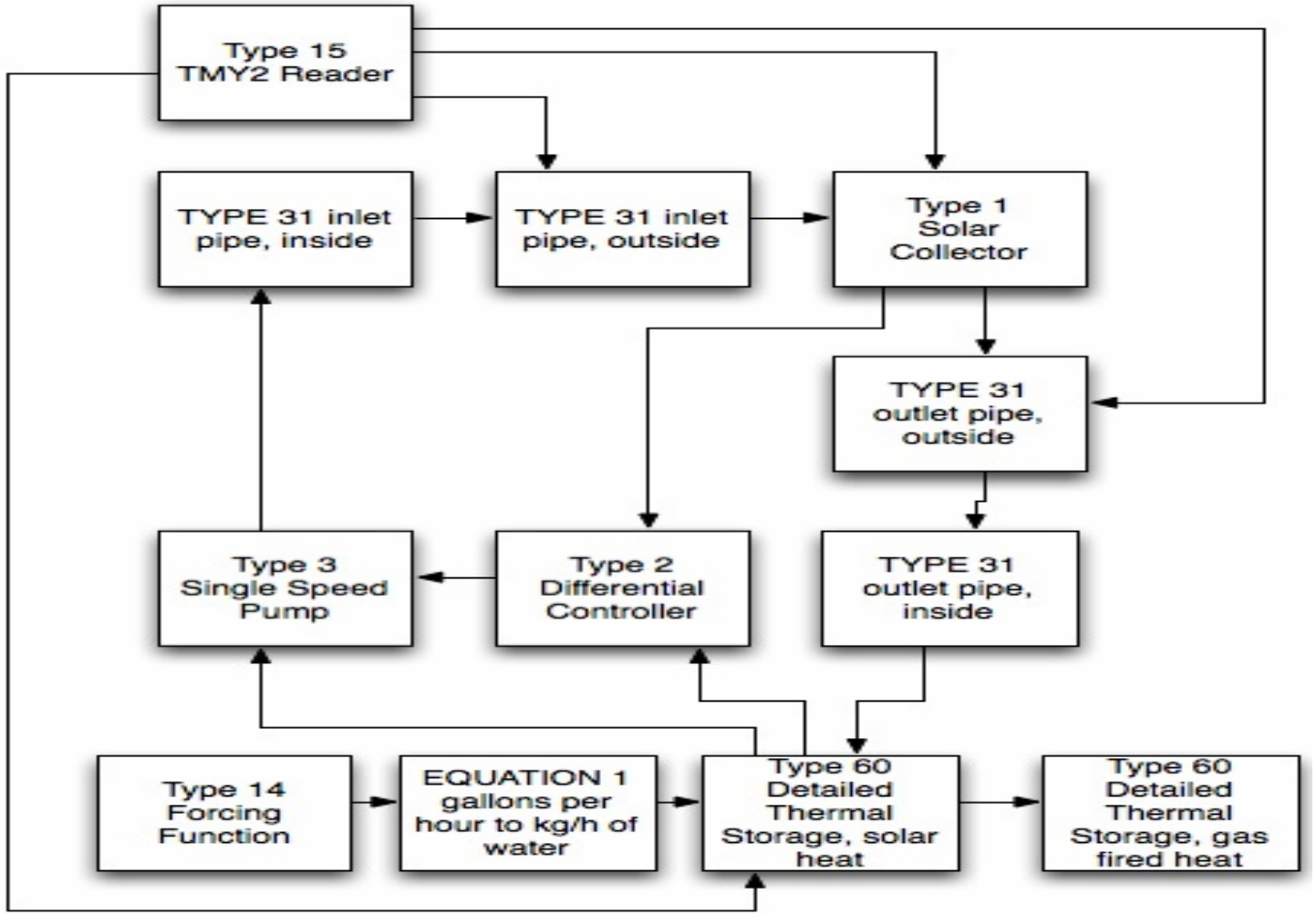
Climatalogical Data

- Irradiance data used as input to sims:
  - TMY-2 data, adjusted to account for high spatial distribution of solar resource derived from geostationary satellites
  - Time series generator (Perez) was used to process original TMY-2 data
  - Updated original 7 NYS sites
  - Extrapolated data for 6 additional sites

Geographical Renditions

- Utilized NCAR Graphics software & Kriging algorithm to produce maps based on long-term averaged global irradiance data.
- Ratio files were created for each of the 26 modeled SDHW systems

TRNSYS Model



Simulation Results

- Baseline loads vary by:
  - System type
  - Location
- All results given in “site” energy use

Simulation Results: Baseline Energy Use in Albany

SYSTEM ID	ENERGY USAGE (MJ)
000-40	25,813
000-80	28,925
001-40	17,036
001-80	17,860
001-120	18,684
002-40	25,813
002-80	28,925
010	18,583
043-105	21,023
043-80	21650

Simulation Results: SDHW Energy Perf. in Albany

Sys ID	E_aux (MJ)	Pump Energy (MJ)		E_disp (MJ)	SF
		Sol	B		
100	9145	403		16668	65%
101	4228	401		12808	75%
102	9145	403		16668	65%
110	4766	401		13817	74%
143	7976	367	58	12990	62%
200	9443	478		16371	63%
201	4293	478		12742	75%
202	9443	478		16371	63%
243	7670	436	56	13925	64%
300	10988	379		14825	57%
301	5310	379		11725	69%
302	10988	379		14825	57%
310	6020	379		12563	68%
330	20873	981		8052	28%
331	8218	660		9643	54%
332	20873	981		8052	28%
343	8620	397	62	12969	60%
520	14169	665		11644	45%
521	8005	665		9030	53%
522	14169	665		11644	45%
530	22151	819		6775	23%
531	8248	660		9612	54%
532	22151	819		6775	23%
610	8322	414		10260	35%

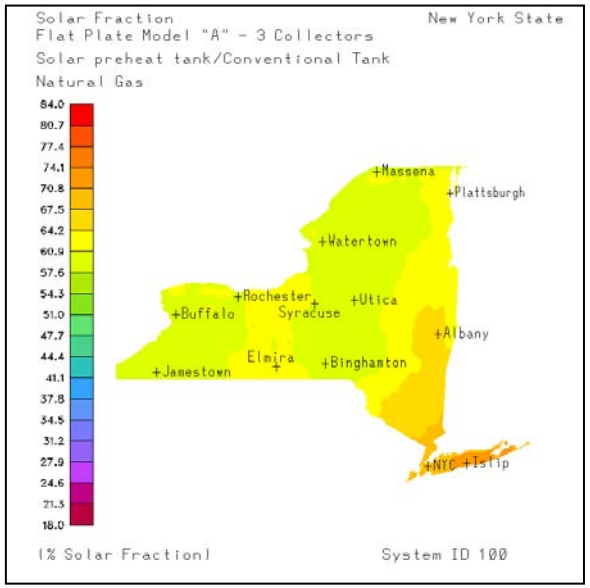
Solar Fraction for common tank (2 tank) & fuel (natural gas) type

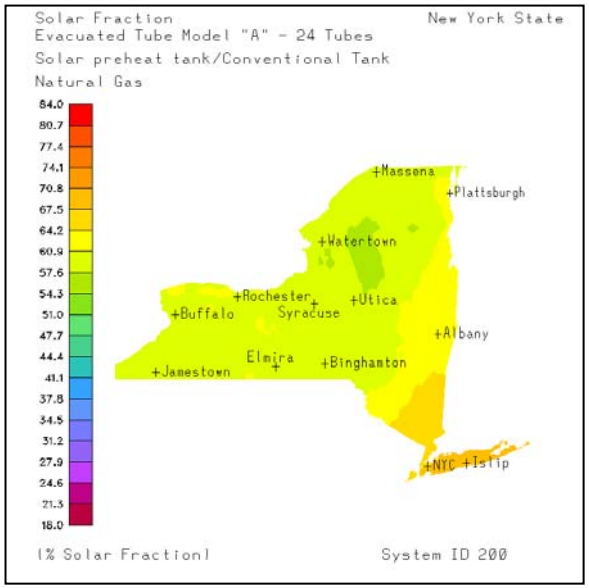
System ID Number	100	200	300	520	600*	700
Albany	65%	63%	57%	45%	47%	33%
Binghamton	60%	59%	52%	41%	42%	30%
New York City	69%	67%	61%	48%	50%	33%
NYS Average	**62%**	**61%**	**55%**	**43%**	**45%**	**32%**

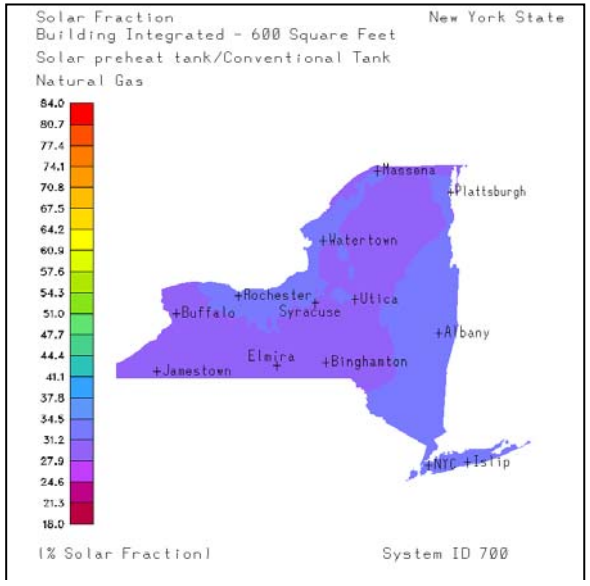
Simulation results: Normalized for collector net aperture area

System ID Number	100	200	300	520	600*	700
Albany	10%	12%	10%	10%	12%	0.6%
Binghamton	9%	11%	10%	9%	11%	0.5%
New York City	11%	12%	11%	10%	13%	0.6%
NYS Average	**10%**	**11%**	**10%**	**9%**	**12%**	**0.6%**

Best-in-technology class SDHW







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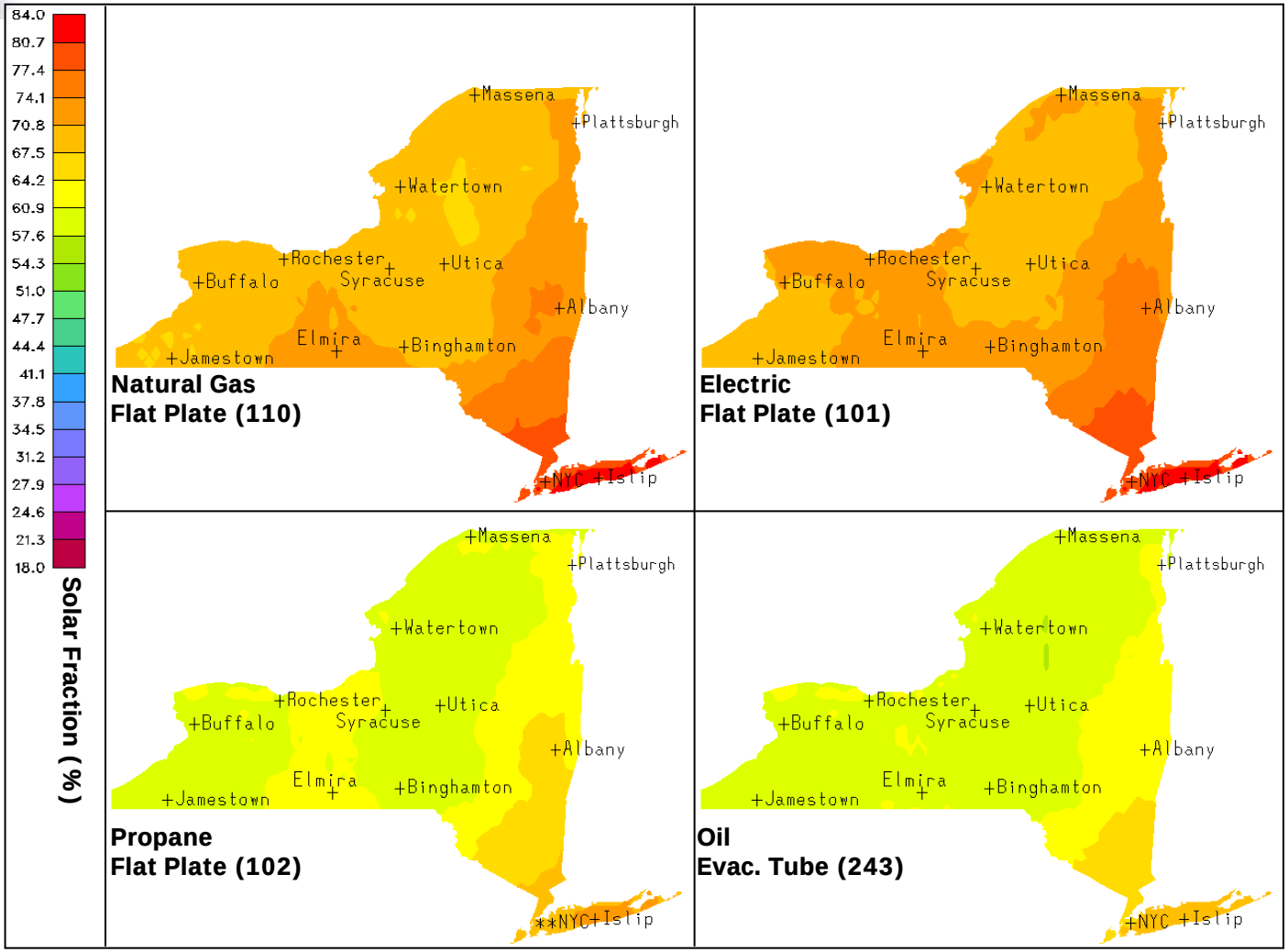
Best-in-fuel class SDHW



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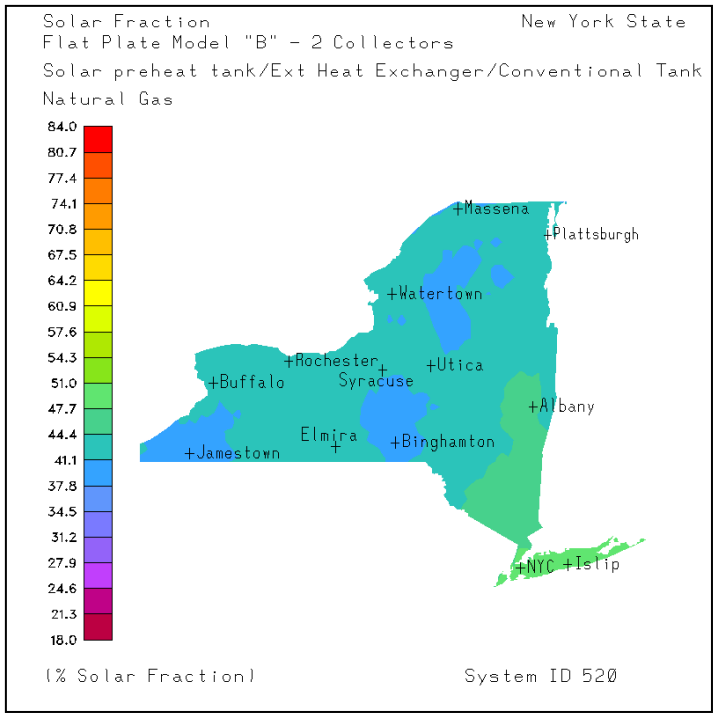
Conclusions

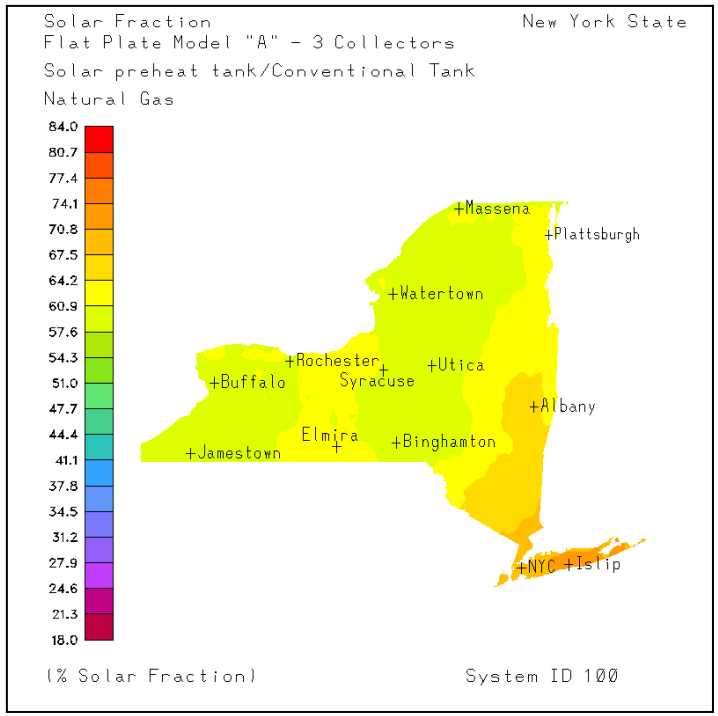
- While this analysis is limited to New York State, it can be seen that SDHW system performance varies by climate, as one would expect, but also by a combination of the interplay between collector type, tank configuration and auxiliary heating fuel.

Conclusions

- General strengths of each technology:
  - Evacuated tube collectors provide the best performance per m^2,
  - Flat plate collectors provide the shortest payback,
  - Building integrated collectors provide the longest life.

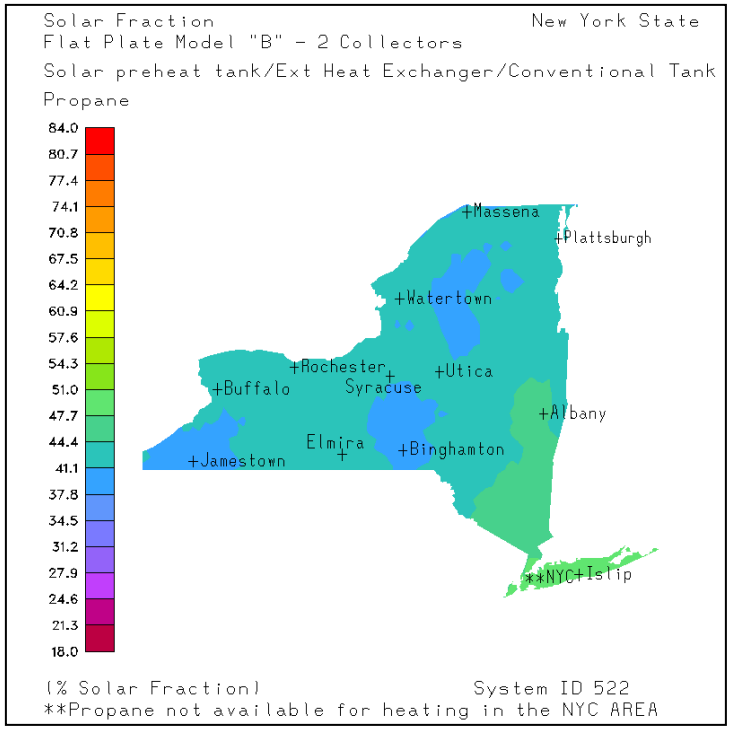
Conclusions

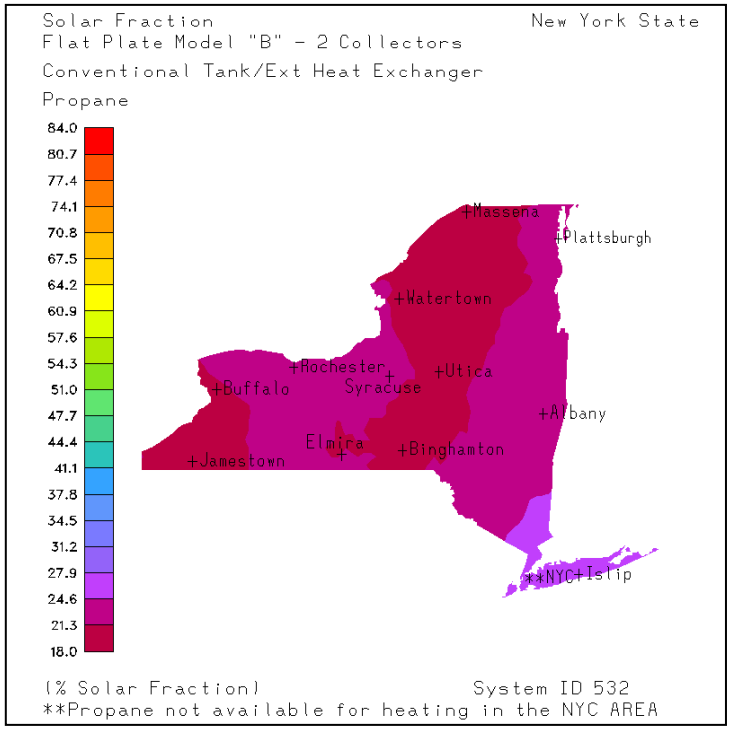




- Manufacturer specified system designs are not necessarily optimally sized; obtaining performance data specific to a given climate and system is key.

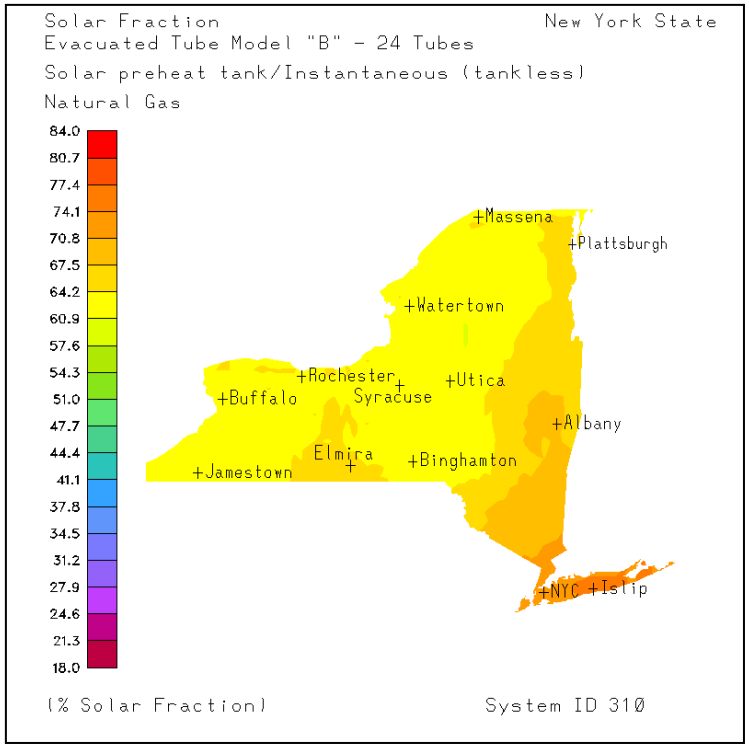
Conclusions

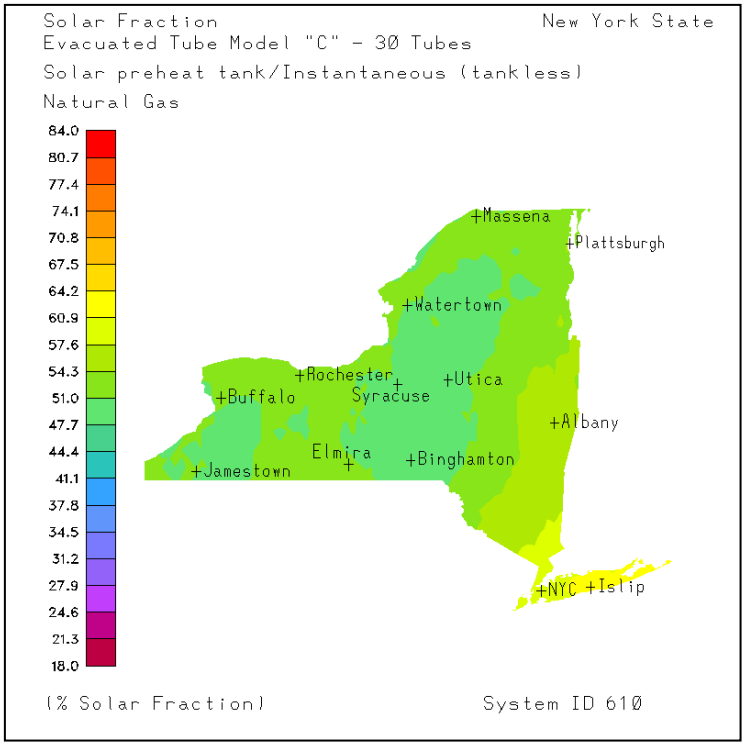




- An external heat exchanger coupled with a single fossil-fuel fired tank does not perform well.

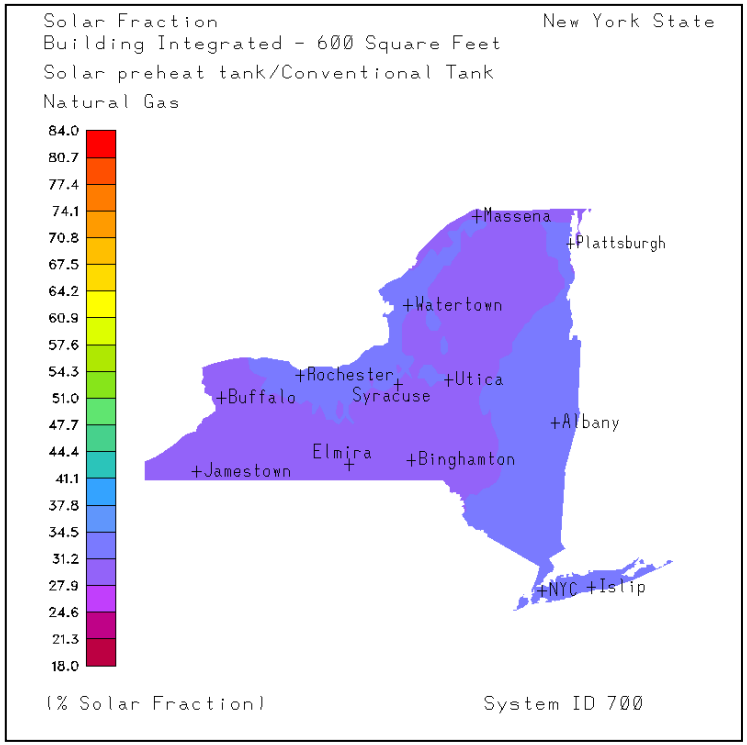
Conclusions

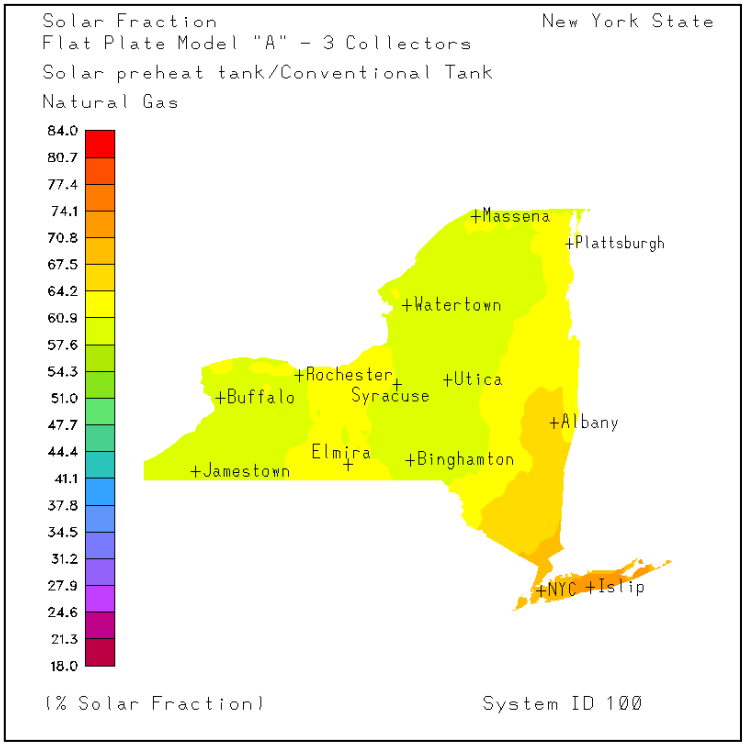




- Similar technologies of collectors, especially with evacuated tubes, can perform quite differently.

Conclusions





- Unglazed building-integrated collectors have more consistent performance throughout the different climate zones analyzed herein.

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Additional Research

- The full version of this NYSERDA-funded study also includes analysis of
  - Installation costs
  - Maintenance costs
  - Payback time
  - Net present value
  - Incentives
  - Market Barriers
- Will be available at http://sdhw.brightpower.biz after final NYSERDA approval (anticipated August 2008)

Thank you!

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- Bright Power is a solar energy and energy efficiency consultancy based in New York City.
- We are growing rapidly and seeking talented, motivated people to join our dynamic team – especially our energy modeling group.

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Questions

Nomenclature

- Each System referred to by a 3 digit number
  - Hundreds Place → collector type
  - Tens Place → tank type
  - Ones Place → fuel type
- For example:
  - Flat Plate Model “A” collector with double heat exchanger tank and fueled by an oil boiler would have a System ID of 143.

Nomenclature

DIGIT	HUNDREDS	TENS	ONES
	COLLECTOR TYPE	**TANK TYPE**	**FUEL TYPE**
0	Baseline	Solar preheat tank + 40 gal (151 L) conventional tank	Natural Gas
1	Flat Plate Model “A” - 3 Collectors	Solar preheat tank + Instantaneous (tankless) heater	Electric
2	Evacuated Tube Model “A” - 24 Evacuated Tubes	Solar preheat tank with External Heat Exchanger + 40 gal (151 L) Conventional Tank	Propane
3	Evacuated Tube Model “B” - 24 Evacuated Tubes	80 gal (303 L) Conventional Tank with External Heat Exchanger	Oil
4	N/A	Double Heat Exchanger Tank	
5	Flat Plate Model “B” - 2 Collectors		
6	Evacuated Tube Model “C” - 24 Evacuated Tubes		
7	600 Square Feet Building Integrated collector (56 m^2)		