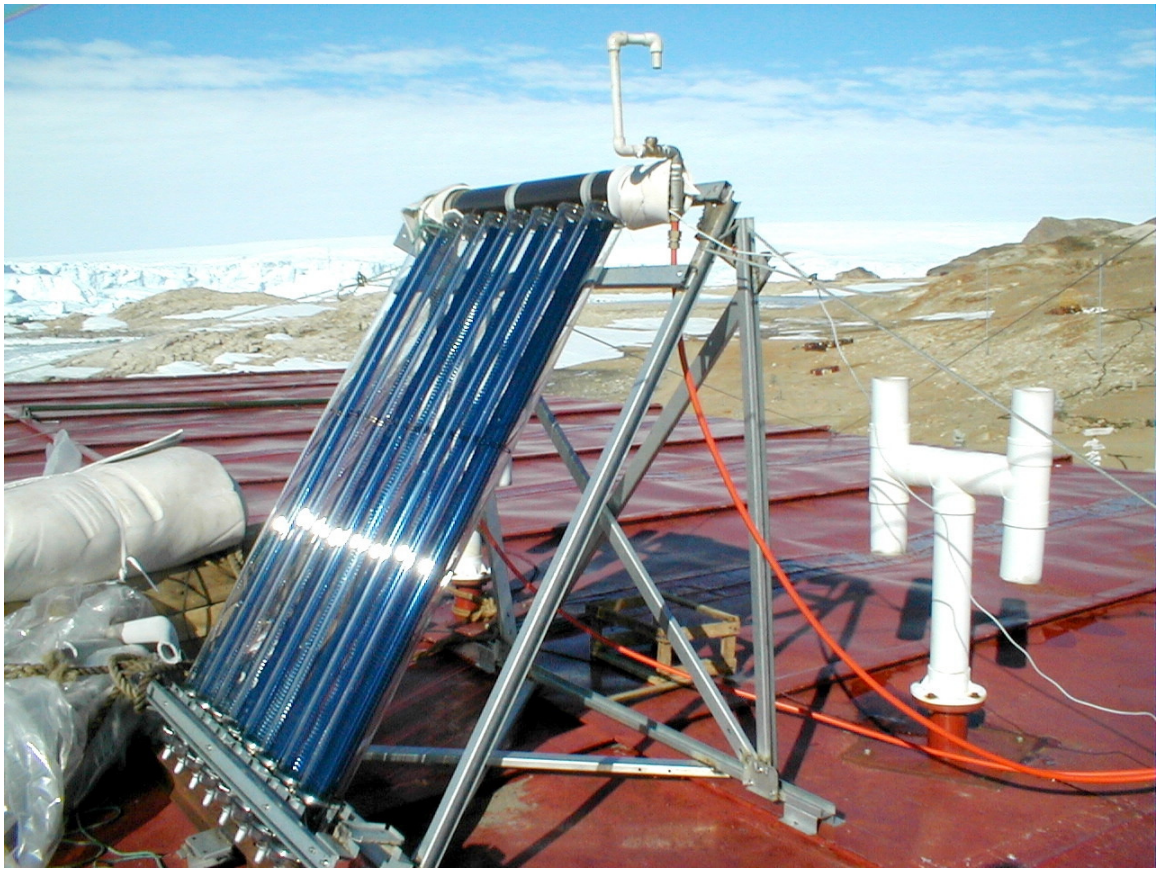
Solar Thermal

Harvey Bowers



Resources

- Steve Eayrs, Eayrs Plumbing and Heating , Homer, 907-235-2333
- E-mail: steve@eayrsplumbingandheating.com
- Alaska Center for Appropriate Technology (ACAT) www.acat.org
- Research Information Center (AHFC) bhall@ahfc.state.ak.us www.ahfc.com full library
- Alaska Solar Tour – Kenai May 14 www.AlaskaSolarTour.org
  Solar Design Manual for Alaska – Rich Seifert, CES www.alaskasun.org free download
- Cold Climate Housing Research Center CCHRC – www.cchrc.org
- Canadian Mortgage Housing Corp CMHC – Case Study #60, Equilibrium www.cmhc.ca
- American Solar Energy Association – www.Solartoday.org
- Home Power – www.homepower.com
- Solar Solutions by Bristol Stickney www.Plumbingengineer.com
- Equipment sales:

1. Alaska Goldstar Plumbing 376-2875

- Ferguson, Viessmann solar systems, Brian Commercial Sales 800-478-7759
- AIS, Anchorage 563-4125 high temperature insulation www.alaskainsulation.com
- Radiant Solar – Pennsylvania, 800-466-7556 www.RadiantHeatPorducts.com
- Oventrop- Proctor Sales, Anchorage 907-562-2608 www.oventrop-na.net
- Heliodyne Solar Hot Water www.heliodyne.com

Renewable Energy Tax Credits

- Solar systems; Small Wind; Geothermal Heat Pumps
  - 30% of cost, no upper limit
  - For existing homes & new construction (no rentals)
  - Expires December 31, 2016

- Windows, doors, water heaters, insulation, HVAC, roofs, biomass
  - 30% of cost up to $1,500
  - For existing principal residence (no new construction or rentals)
  - Expires December 31, 2016

- Commercial Solar Projects
  - 30% of cost, no upper limit
  - Treasury grants up to 30% of cost also available
  - Expires December 31, 2016

Solar Hot Water Collectors are certified by the SRCC:
Solar Rating & Certification Corporation

SOLAR COLLECTOR CERTIFICATION AND RATING

SRCC OG-100

CERTIFIED SOLAR COLLECTOR

SUPPLIER: **Beijing Sunda Solar Energy Technology Co Ltd**
No. 3 Hua Yuan Road
Beijing, 100083 China

MODEL: SEIDO 5-16 AS/AB

COLLECTOR TYPE: SUNDA Tubular

CERTIFICATION#: 2006026B

COLLECTOR THERMAL PERFORMANCE RATING

Megajoules Per Panel Per Day				Thousands of BTU Per Panel Per Day			
CATEGORY (Ti-Ta)	CLEAR DAY	MILDLY CLOUDY	CLOUDY DAY	CATEGORY (Ti-Ta)	CLEAR DAY	MILDLY CLOUDY	CLOUDY DAY
A (-5 °C)	45.0	34.0	23.0	A (-9 °F)	42.6	32.2	21.8
B (5 °C)	42.4	31.4	20.5	B (9 °F)	40.2	29.8	19.4
C (20 °C)	38.3	27.4	16.5	C (36 °F)	36.3	26.0	15.7
D (50 °C)	30.6	19.6	9.5	D (90 °F)	29.0	18.6	9.0
E (80 °C)	22.8	12.6	3.0	E (144 °F)	21.6	12.0	2.8

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

Original Certification Date: 11-OCT-06

COLLECTOR SPECIFICATIONS

Gross Area:	4.097 m^2	44.09 ft^2	**Net Aperature Area:**	1.38 m^2 14.86 ft^2
Dry Weight:	105.0 kg	232. lb	**Fluid Capacity:**	1 liter 0.3 gal
Test Pressure:	1000. KPa	145. psig		

COLLECTOR MATERIALS

Frame: Stainless Steel
Cover (Outer): Glass Vacuum Tube
Cover (Inner): None

Pressure Drop

Flow		ΔP	
ml/s	gpm	Pa	in H_2O

Absorber Material: Tube - Copper / Plate - Aluminum
Absorber Coating: Sputtered aluminium nitride
Insulation Side: Vacuum
Insulation Back: Vacuum

TECHNICAL INFORMATION

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

				Y INTERCEPT	SLOPE
S I UNITS:	**η= 0.489**	**-1.58550 (P)/I**	**-0.00524 $(P)^2/I$**	**0.492**	**-1.924 $W/m^2.°C$**
I P UNITS:	**η= 0.489**	**-0.27929 (P)/I**	**-0.00051 $(P)^2/I$**	**0.492**	**-0.339 $Btu/hr.ft^2.°F$**

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

K&tauα = 1	0.947 (S)	-1.076 $(S)^2$	**Model Tested:**	SEIDO 5-8 AS/AB
K&tauα = 1	-0.18 (S)	Linear Fit	**Test Fluid:**	Water
			Test Flow Rate:	10.0 ml /$s.m^2$ 0.0147 gpm/ft^2

REMARKS: Tested with long axis of tubes oriented north-south. IAM perpendicular to the tubes is listed above. IAM parallel to the tubes = 1.0 - 0.32(S)

SOLAR HOT WATER … IN ALASKA

-3 TO 4 TIMES MORE EFFICIENT IN CAPTURING SOLAR ENERGY THAN PV PANELS (30-70% vs 10-20%)

-– A GREAT MATCH FOR AK SUMMERS BUT A CHALLENGE IN LOW WINTER SUN & COLD

- MUST BE SOUTH FACING AND NO SHADE, STEEP TILT, SOUTH WALL OR OVERHEAD ROOF TO KEEP OFF SNOW IN WINTER

- CLOSED LOOP SYSTEM – USE GLYCOL ANTI-FREEZE SYSTEM

Sun Path

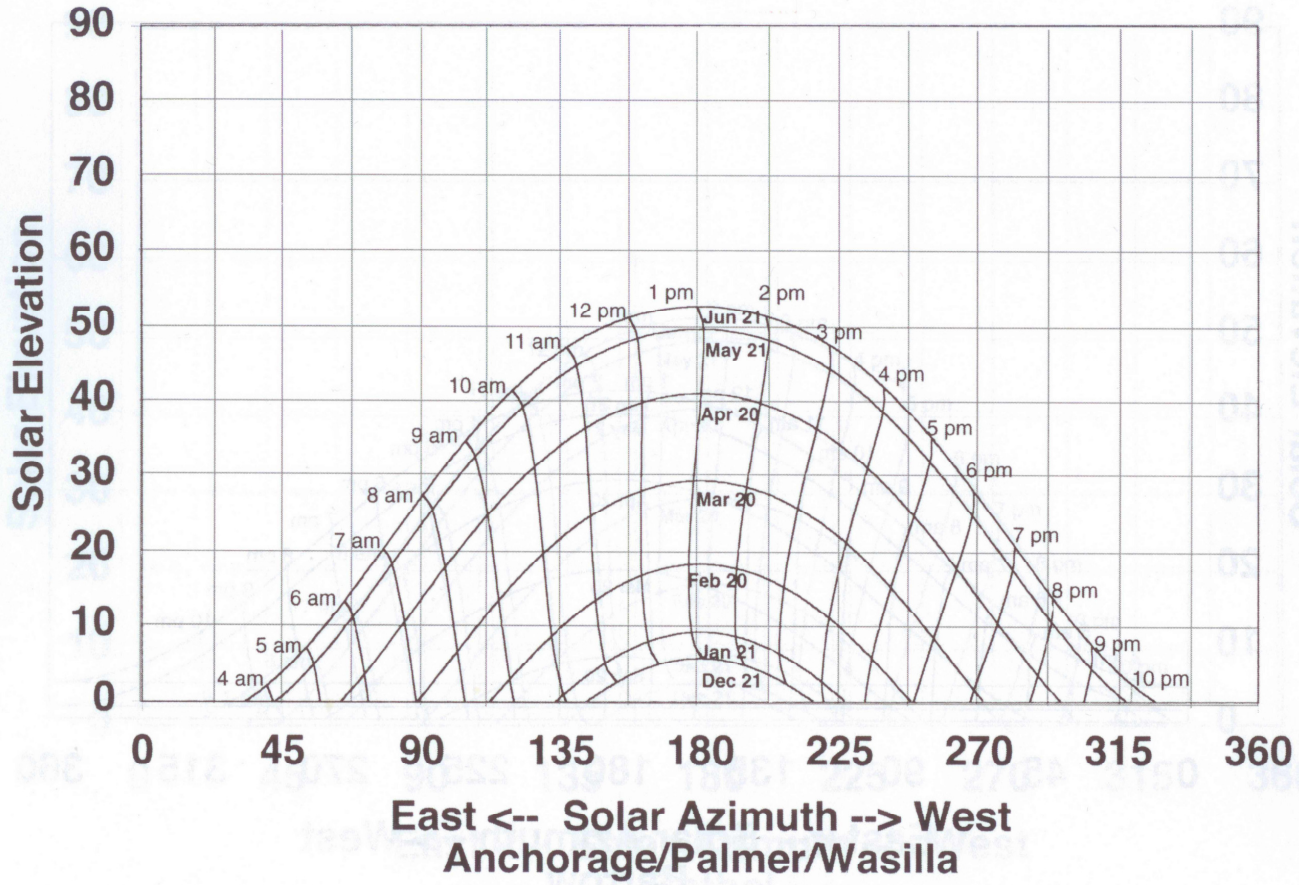
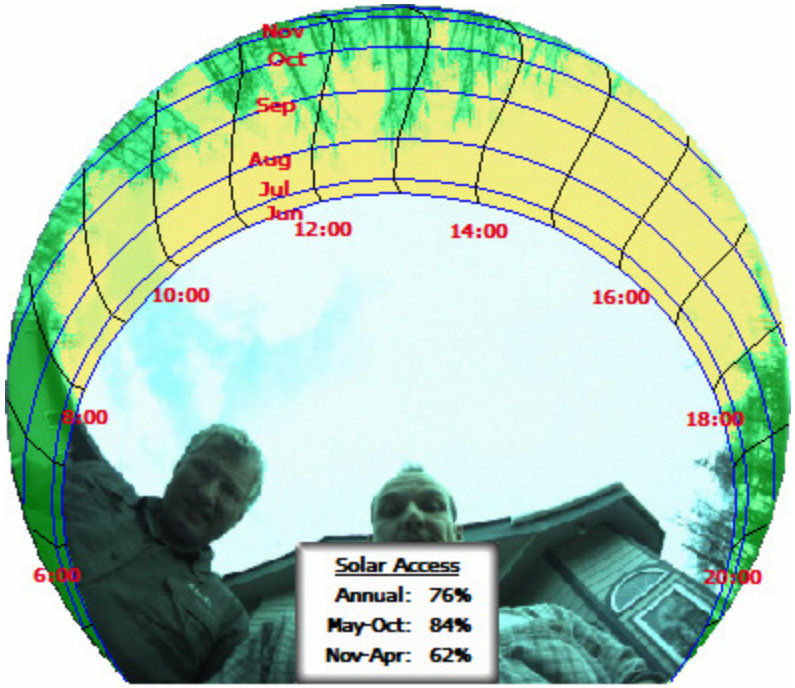
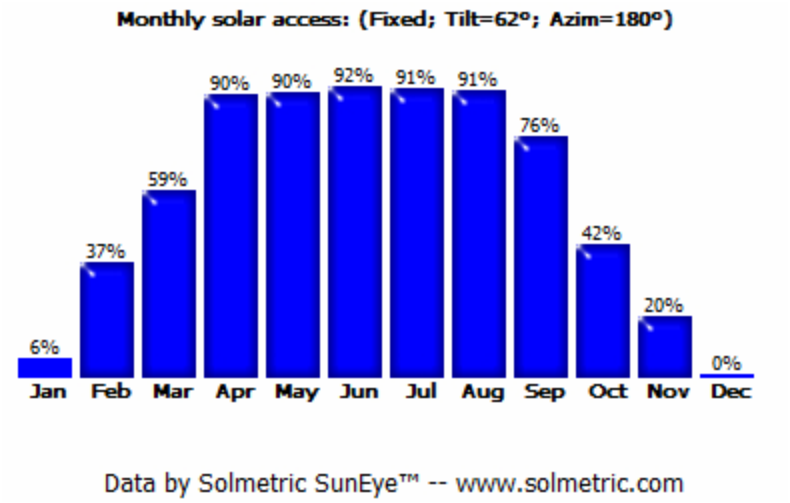


Figure 36. Sun path diagram for Anchorage/Palmer/Wasilla, Alaska. Latitude: 61 N; Longitude: 150 W.



Data by Solmetric SunEye™ -- www.solmetric.com


Monthly solar access: (Fixed; Tilt=62°; Azim=180°)
6%
37%
59%
90%
90%
92%
91%
91%
76%
42%
20%
0%
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Data by Solmetric SunEye™ -- www.solmetric.com

Tilt and Angle Effect

TABLE 9: EFFECT OF TILT AND AZIMUTH ANGLE ON SOLAR COLLECTOR PERFORMANCE.[1]

Fairbanks, Alaska 64°49′N						Matanuska, Alaska 61°34′N					
Water Heating Only[2]			Space and Water Heating[3]			Water Heating Only[2]			Space and Water Heating[3]		
Azimuth (degrees)	Tilt (degrees)	Annual Solar Contribution %	Azimuth (degrees)	Tilt (degrees)	Annual Solar Contribution %	Azimuth (degrees)	Tilt (degrees)	Annual Solar Contribution %	Azimuth (degrees)	Tilt (degrees)	Annual Solar Contribution %
0	64	54	0	64	27	0	61	63	0	61	41
0	54	55	0	74	26	0	51	63	0	71	40
0	44	54	0	84	24	0	41	62	0	81	38
0	34	53	0	89	23	0	31	59	0	89	36
0	24	51	0	54	27	0	21	56	0	51	41
0	0	44	0	44	27	0	0	47	0	41	39
10	64	54	10	64	26	10	61	63	10	61	40
20	64	54	20	64	26	20	61	62	20	61	40
30	64	53	30	64	26	30	61	61	30	61	39
40	64	52	40	64	25	40	61	60	40	61	38
50	64	51	50	64	25	50	61	58	50	61	36
40	44	53	40	44	25	40	41	59	40	41	37

[1] F-chart computer simulations were used to develop this table. Collectors were not at tilts greater than latitude for water heating because smaller angles are more efficient on an annual basis. However, nearly vertical tilts are optimum for space heating since they maximize winter capture of solar energy.

[2] 150 ft^2 collector area.

[3] 400 ft^2 collector area.

Energy Costs

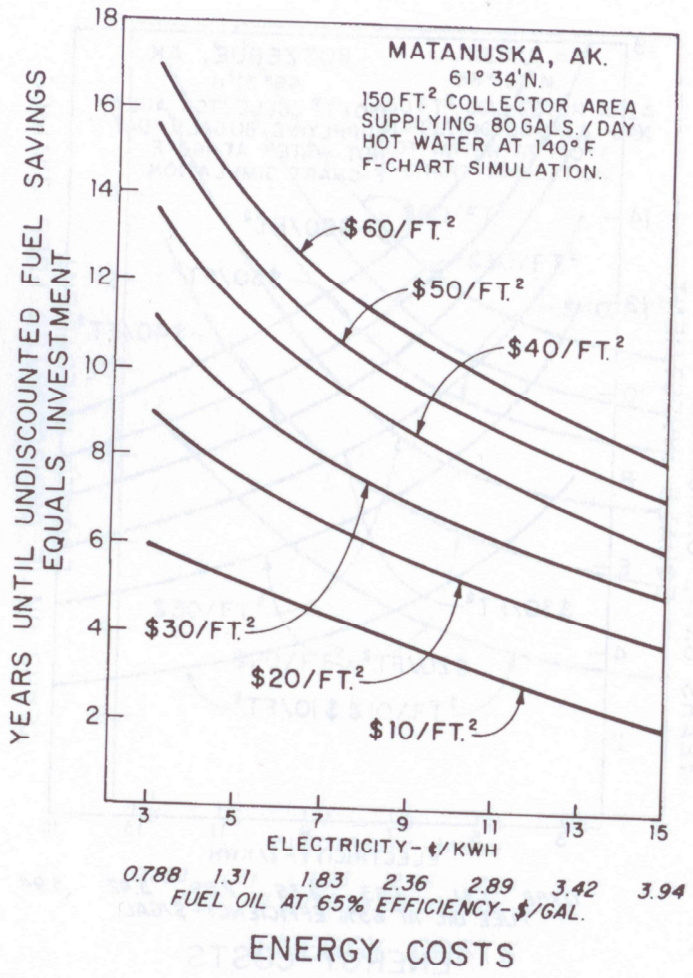


Figure 27. Payback period for solar domestic water heating system in Matanuska, Alaska.

Power output 220 Watts

problem panel

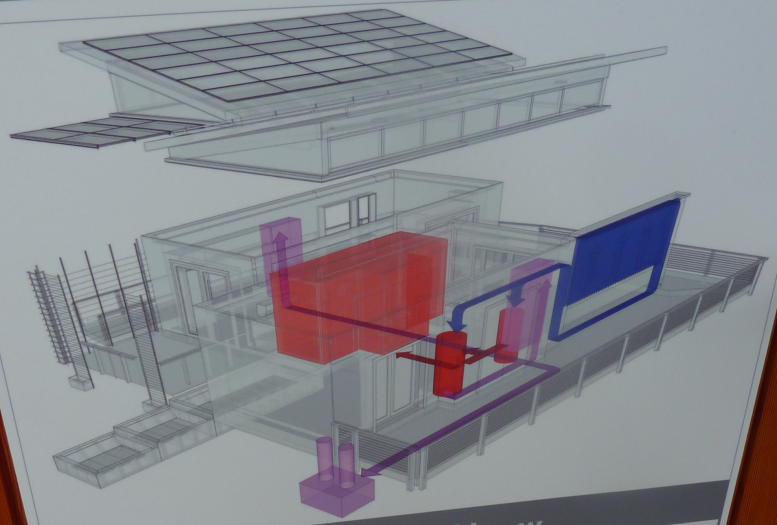
2 The Enphase M210 Microinverters

- Converts DC to AC power
- Decreases DC wire
- Increases efficiency
- 95.5% CEC efficiency

3 Main service panel

4 Sub-service panels

- Individual sub-panels minimize connections
- Facilitate modularity
- Facilitate transportation
- No added breaker or disconnects with PV system



solar thermal flow

WaterShed integrates a solar thermal array to collect thermal energy for hot water heating, liquid desiccant regeneration, and air heating (HEXST system).

Solar Thermal Energy

1 Paradigma CPC 45 Star Azzura Solar Thermal Tube Panels

- Collect solar energy as heat
- Heat is stored and used for liquid desiccant regeneration, supplemental space heating, and hot water needs
- Produces 30% more energy than other similar-sized arrays because of tube efficiency
- Generates 1.06 kBTU per panel

Liquid Desiccant Regenerator & Excess Solar Thermal Energy

2 Liquid Desiccant Regenerator

- Heat from solar thermal array regenerates liquid desiccant
- Requires temperature up to 180 °F for liquid desiccant regeneration

3 Heat Exchanger for Excess Solar Thermal (HXEST)

- Built into LDW cabinets
- Utilizes excess solar thermal energy for supplemental space heating

Hot Water Heating

4 StorMaxx Ptec 1052HX Storage Tank

5 A.O. Smith Sunx 80 Electric Water Heater

- Durable
- Exceptional thermal performance
- Extra storage allows solar hot water to bridge period with limited solar input

6 Plumbing core

- Uses Polyethylene (PEX) tubing
- Quick installation
- Simple connections
- Affordable
- PEX manifold
- Reduces plumbing runs

U.S. DEPARTMENT OF ENERGY SOLAR DECATHLON

U.S. DEPARTMENT OF ENERGY

NREL


Preheat Tank
HVI
Network Switch
Microcontrollers
Unit 0
Unit 1
Unit 2
Unit 3
D/A & Counter
easy


Hot Water Storage Tank
Sprinkler Pump

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ADA-Compliant Under-the-Sink Lavatory Pipe Insulation

The SunRise Home

Masonry Heater

Vac Tube

Mat-Su Data

kWh/m²/Day

Month	Global Radiation	Mean Outside Temperatu
	[kWh/m²/Day]	[°F]
Jan	0.3840	13.2800
Feb	1.0800	18.1400
Mar	2.8080	23.3600
Apr	4.1520	35.7800
May	5.0640	45.8600
Jun	5.3760	54.1400
Jul	4.7520	57.3800
Aug	3.6480	55.5800
Sep	2.3040	47.6600
Oct	1.1520	35.4200
Nov	0.4320	21.9200
Dec	0.1680	13.4600
Year	31.3200	35.1650

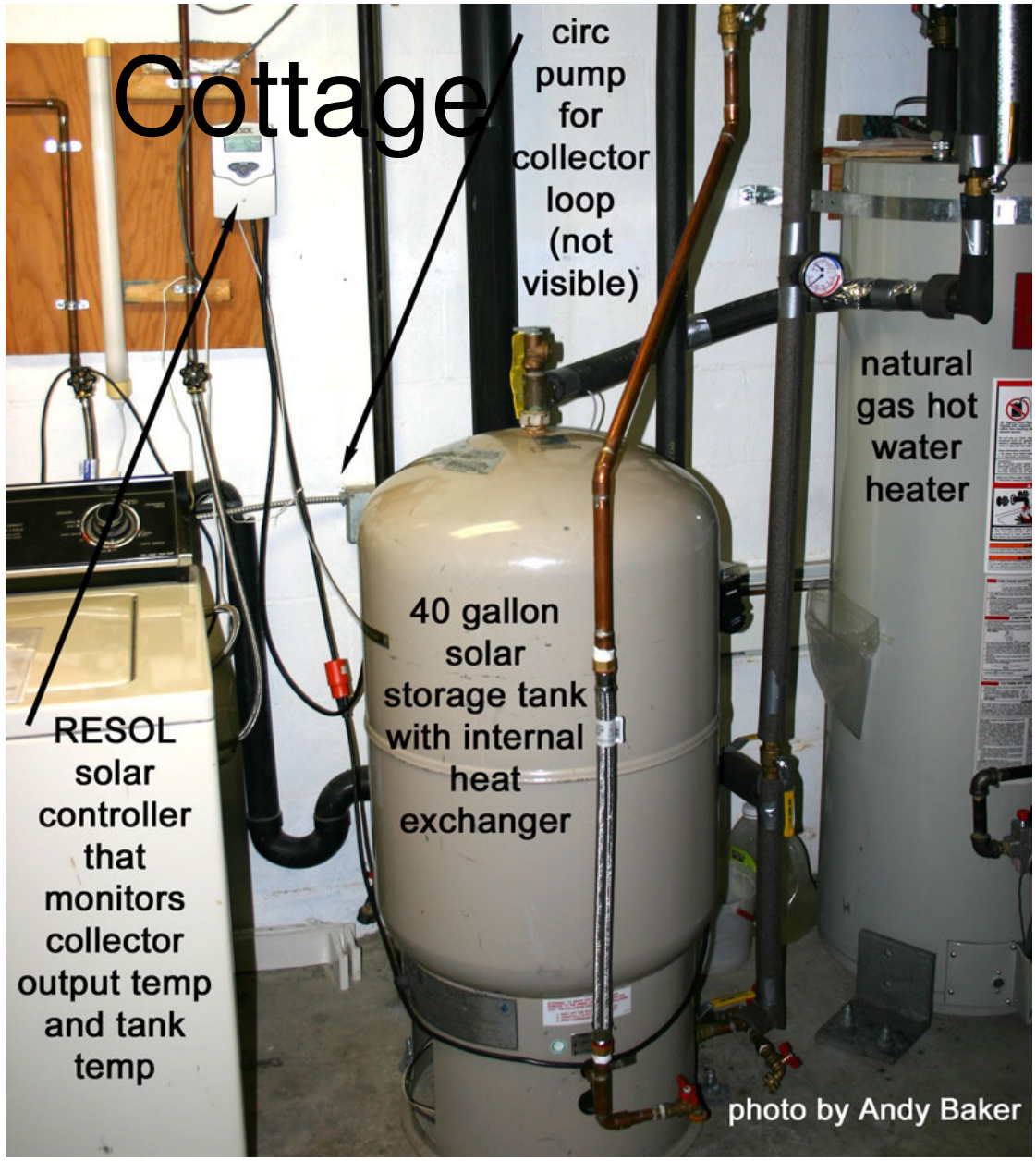
Sunda Seido 5-16 AS

Absorber surface 3.6m² (38.75 sf)

Max temp 190 C; Operating 247 C

Cottage Building Information

- 1,600 sf heated
- 1980 built as an all electric cabin
- 1999 Natural gas water heater, fireplace & unit heater installed
- 2008 installed solar system
- Solar vacuum tubes aimed South at 80 degree tilt
- Sunda 5-16 is 38.75 sf (3.6 m^2) (recommended 4 tubes/person)
- Rated by Solar Collecting Certification & Rating – SRCC OG-100
- Cloudy day solar production - 10,000 to 20,000 BTU/day
- Clear day solar production - 20,000 to 40,000 BTU/day


Cottage
circ pump for collector loop (not visible)
natural gas hot water heater
40 gallon solar storage tank with internal heat exchanger
RESOL solar controller that monitors collector output temp and tank temp
photo by Andy Baker

Sizing Example:

Annual % hot water for average home in Mat-Su (lat. 61 degrees 34 minutes)
150 sf collector = delivers approximately 62.6% of hot water needs

Domestic Hot Water (DHW) assumes 20 gallons first 2 people; 15 gallons each additional
1 Btu raises 1 lb of water 1 degree F

- Determine temperature rise (delta T)
  Delta T = 120 – 40 = 80 deg F Temperature Rise

- Determine energy requirements (water tank volume in gallons)
  80 gallon = 667.2 lb (1 gal = 8.34 lb of water = 0.1337 cu ft)
  667 lb * 80 deg F = 53,360 Btu/day

- Determine solar collector output / tube
  1,000 * 0.70 conversion = 700 Btu/sf/day of collector absorber
  700 Btu/sf/day * 2.42 sf area/tube = 1694 Btu/tube/day

- Determine tube requirements
  53,360 Btu/ 1694 Btu/tube/day = 32 tubes or 2 collectors

Building Codes:
ASHRAE – 90003 Active Solar Heating Design Manual
ASHRAE – 90342 Active Solar Heating Systems Installation Manual
ASHRAE – 90336 Active Solar Heating Systems Operation & Maintenance Manual
NFPA 70 – National Electrical Code

Solar System Costs

- Sunda Seido 5-16 $1,790
- Roof mount kit$ 218
- Pump – Laing** $ 150
- Shipping $ 300
- Heat Exchange tank* $ 0
- Controller – Resol BS/1 3 sensor $ 146
- Amtrol model 15 expansion tank $ 35
- Pipe insulation $ 55
- Check valves – 2 $ 30
- Pressure relief valve $ 15
- Ball valves – 4 ¾ inch $ 40
- Air vent $ 20
- Drain – ball valves ¾ MPT $ 32
- Pressure gauge $ 15
- Labor – 2 days hired $ 400

Total cost $3,246

* Normal range $900 to $1,400

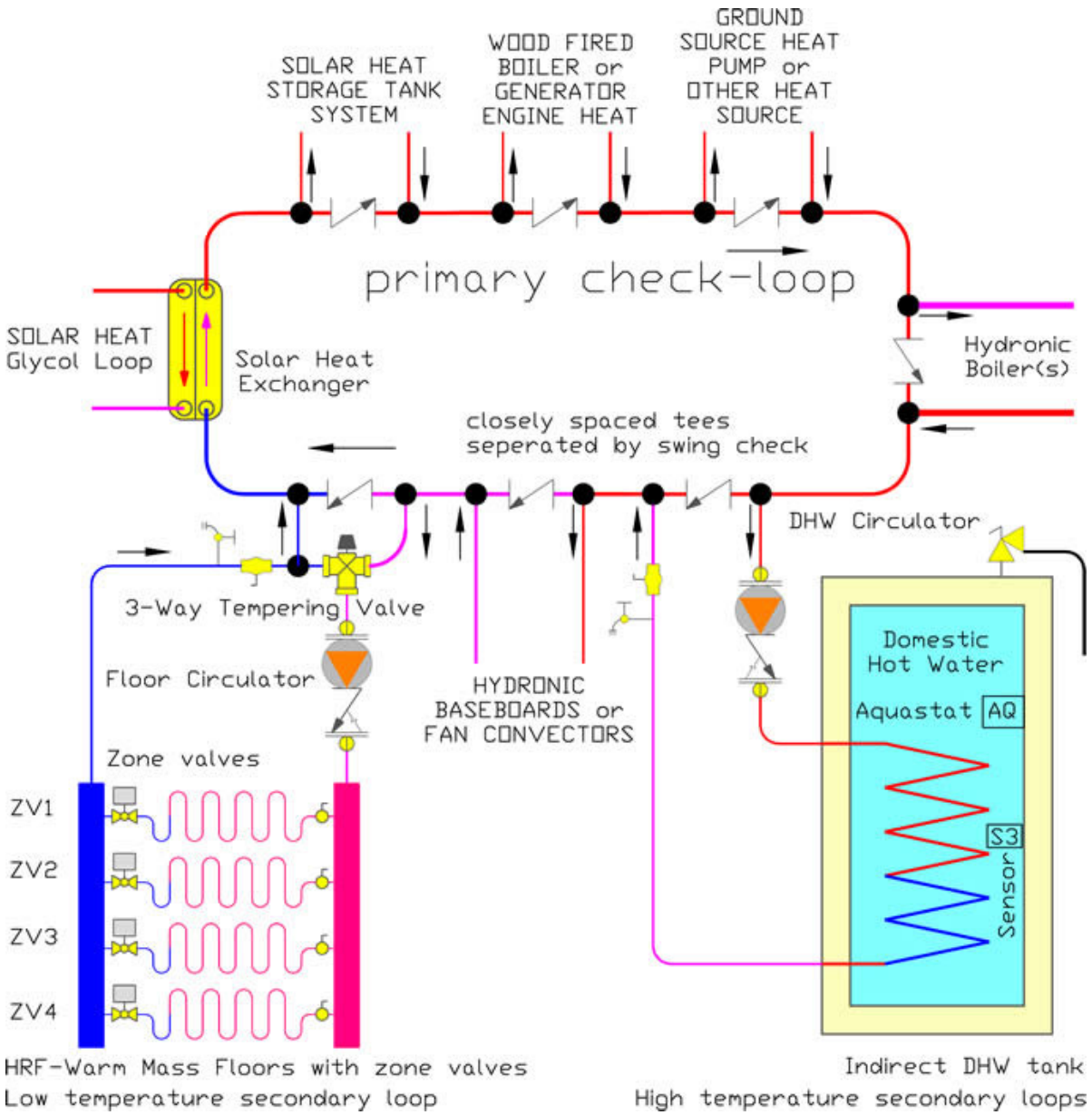
** Laing circulation pump SM303-B magnetic pump, 33 watts, 1/150 hp, 115 votes .3 amps, can handle a pipe loop of 350 feet ½”

Cottage Occupancy & Utility Use

Year	% Occupied	Electric Use	Electric Cost	Natural Gas Use	Natural Gas Cost
2005	16% Summer only	1247 kwh	$218 .175/kwh	1043 ccf	$658 .63/ccf
2006	17% Summer only	1404 kwh	$245 .175/kwh	1043 ccf	$748 .72/ccf
2007	13% Summer only	1328 kwh	$232 .175/kwh	971 ccf	$748 .77/ccf
2008	17% Summer only	1503 kwh	$268 .178/kwh	1097 ccf	$987 .90/ccf
2009	79% Year round	2952 kwh	$530 .18/kwh	1035 ccf	$1134 1.10/ccf

Note: Solar thermal installed mid-2008. Before Solar thermal, if occupied 79% Gas cost would have been closer to $2,000

Solar Solutions

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