Sea Water Heat Pump Project

Alaska SeaLife Center, Seward, AK

Presenter:

Andy Baker, PE, YourCleanEnergy LLC

JCOS Forum – Juneau Library – April 11, 2013

YourCleanEnergy LLC - Mission

- **<u>History:</u>** **Providing clean energy consulting (financial evaluation & design) services to commercial and municipal clients in Alaska since 2006.**
- **Specialize in sea water heat pump evaluation & design; development, evaluation and design of heating districts.**
- **Successful clean energy projects are ones that are:**

- **Affordable Reliable Safe**

Your Clean Energy

Celebrate the power of nature...TM

What Are Sea Water Heat Pumps?

Water source heat pumps that tap the ocean directly for heat

- **Not to be confused with Ocean Thermal Energy Conversion**
- **Immense solar energy travels 93 million miles from the sun to reach the earth's surface, where it is both absorbed and reflected**
- **Most of the solar heat reaching earth is absorbed directly by the ocean, or indirectly from fresh water flow, or from heated air.**
- **In Alaska, many ice free bays have year round sea water temps greater than 35F. This is utility grade heat source ready to tap.**

History Of Proven Technology

Vapor Compression Refrigeration cycle has been used commercially for more than 100 years (this cycle is used by heat pumps)

First northern latitude application of sea water heat pumps was in 1981 with residential district loop in Haugesund, Norway

This has been followed by installations in Bodo & Bergen Norway; Stockholm, Sweden; and Helsinki, Finland

BC Canada just south of Juneau now has several large installations in the Vancouver area, including Vancouver Convention Center, Gulf Islands Natl Park Center, and Whistler Athletes Village

Alaska now has Auke Bay Lab (NOAA) & Alaska SeaLife Center

Technology Overview

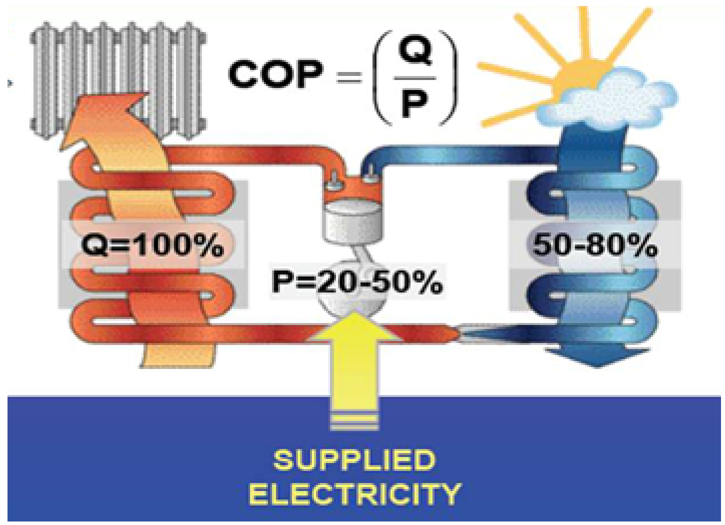
The Seawater Heat Pump

Emerging Technology That Moves Thermal Energy

Heating

- Space Heating
- Hot Water
- Ventilation Air

90 F to 120 F



Source

Alaska Seawater With Temps Ranging From 37 F to 52 F

Q = Quantity of heat produced by heat pump

P = Electrical power used by heat pump

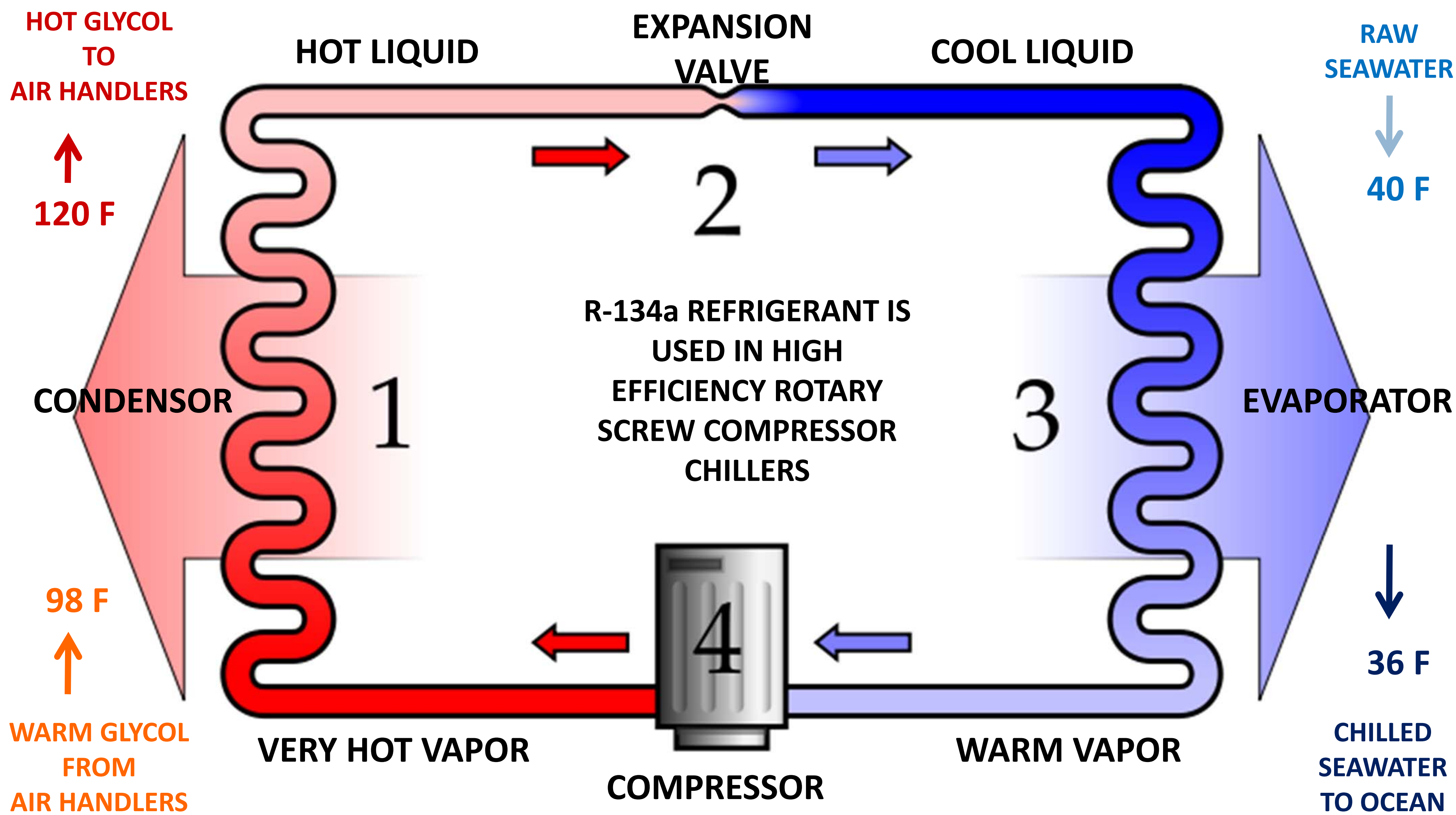
COP (Coefficient of performance) of 3.1 – 3.6 expected from ASLC seawater heat pump

Sea Water Heat Pump Systems – Norway, Sweden & Canada

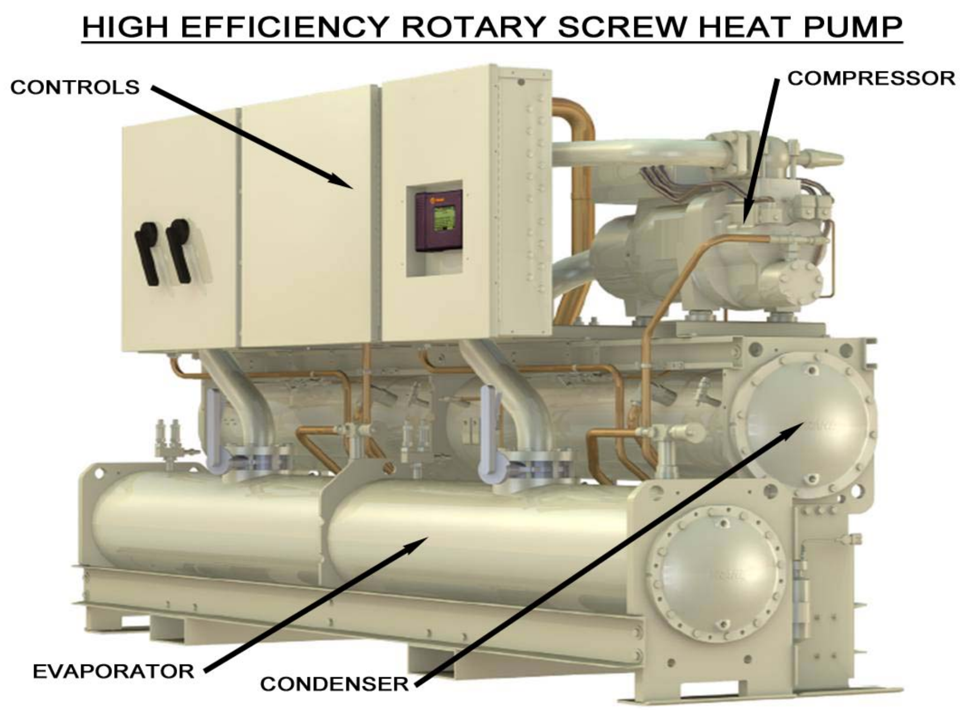
The concept of using heat from seawater for building demands has been employed for nearly 20 years in fjords along the coast of Scandinavia:

- **Stockholm, Sweden = Vartan Ropsten = largest seawater heat pumps on the planet**
- **Bodo Norway, pop 41,000, district heating w/44.6F seawater – on military base**
- **STATOIL Research Centre, Trondheim, Norway, district heating with seawater**
- **Vancouver West Convention Centre, Downtown Waterfront**

Technology Fundamentals



Key Technology Component



Emerging technology with more efficiency & lower maintenance

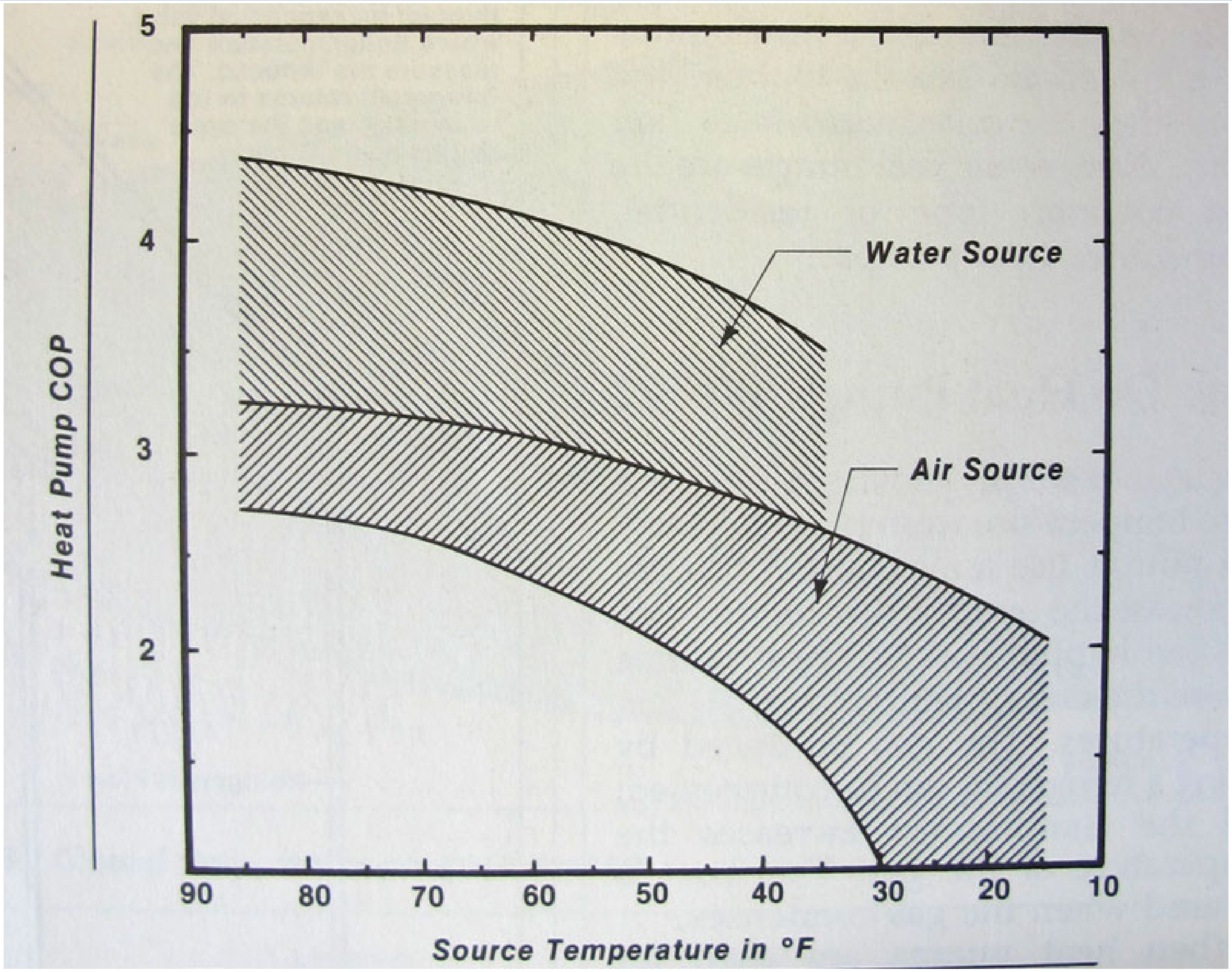
Single packaged unit can now perform complex heat pump functions with high reliability and serviceability

Can be operated and supported with automated controls and web based monitoring

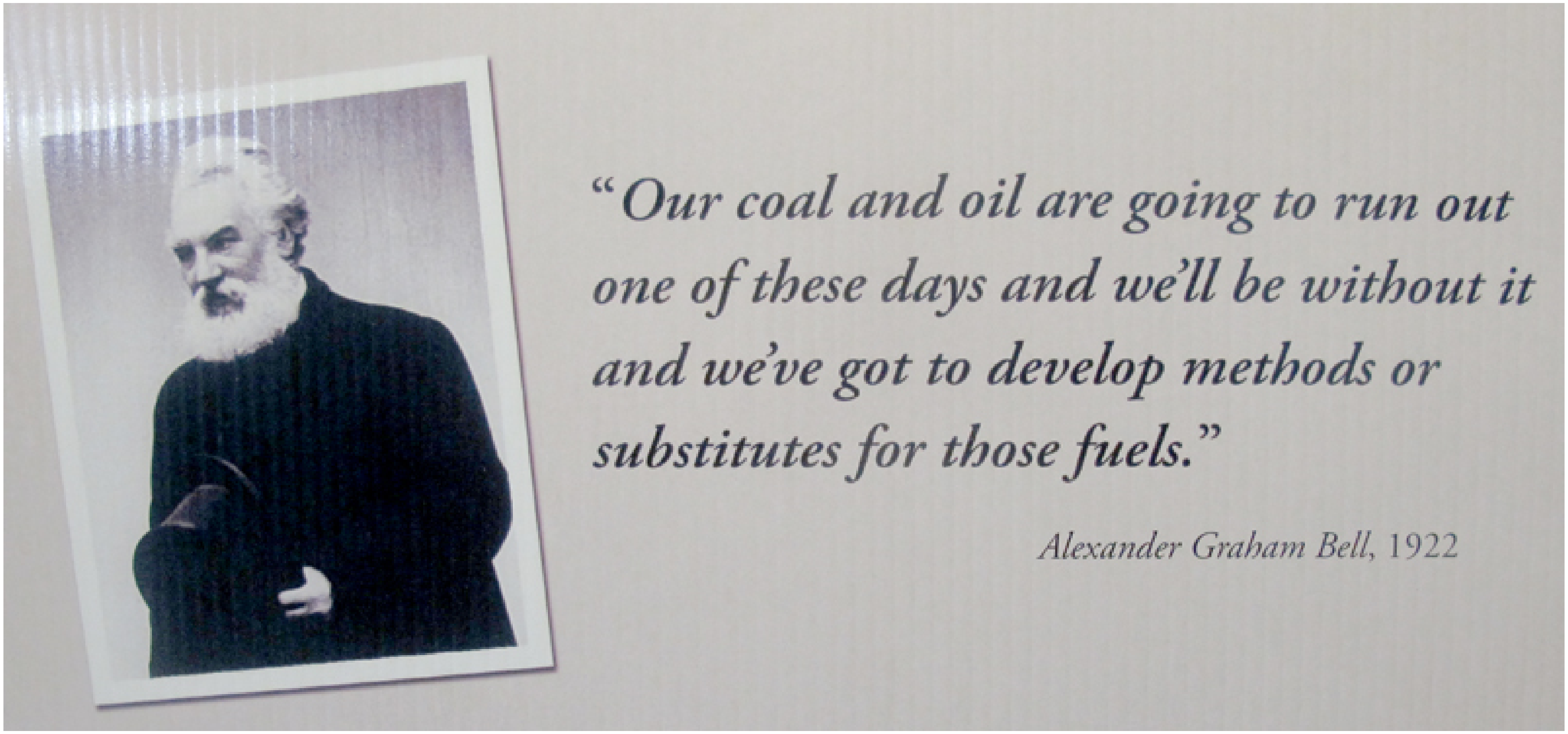
Expected Technology Performance

Month	Entering Evaporator deg F	Heating MBH (output)	kW (input)	COP
Jan	41.2	955.9	81.94	3.42
Feb	39.3	921.4	81	3.33
March	38.2	901.4	80.46	3.28
April	37.8	894.2	80.26	3.26
May	38.1	899.6	80.41	3.28
June	39	915.9	80.85	3.32
July	39.6	926.8	81.15	3.35
August	40.3	939.5	81.49	3.38
September	43.7	1001.6	83.17	3.53
October	45.8	1040.3	84.21	3.62
November	45.6	1036.8	84.11	3.61
December	43.3	994.2	82.97	3.51
Worst	35	843.7	78.89	3.13

Water Source vs. Air Source Heat Pumps



Heat Pumps Can Provide Viable Option To Oil



Alaska SeaLife Center

Alaska SeaLife Center

Economic Profile of the Center

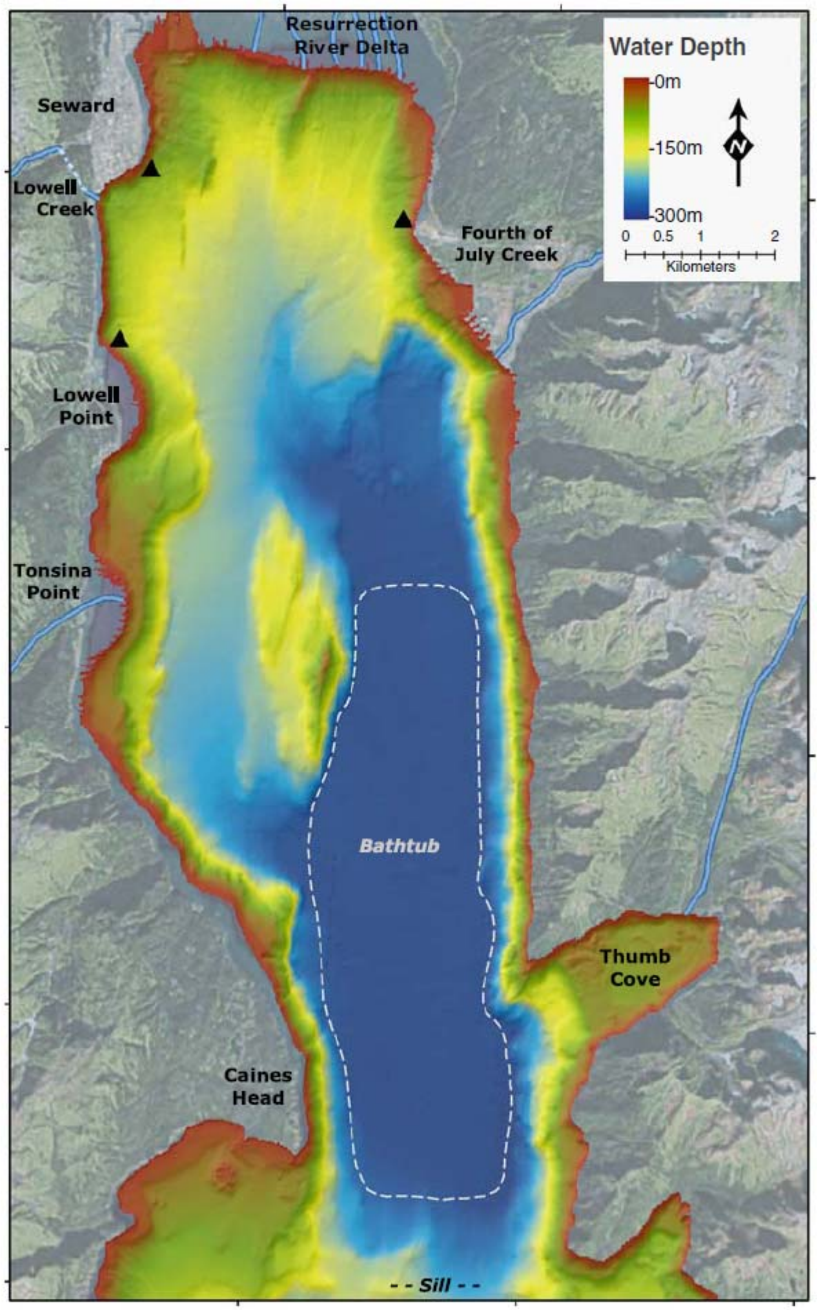
- $4.77 million in annual payroll
- 90 year round employees
- Largest private employer in Seward, and 11th largest on Kenai Peninsula
- Year round tourism for South Central Alaska: 160,000 visitors/yr

Goals = Reduce Energy Cost & Carbon Emissions

Energy Use Profile for the 120,000 sq ft Alaska SeaLife Center:

- **Heating loads are large = air handlers, baseboards, duct coils, pavement heating, domestic hot water**
- **Two oil fired boilers plus one electric boiler in plant**
- **Heating oil demand can exceed 500 gallons per day in winter and up to 132,000 gallons per year.**
- **In 2008 with $5/gallon pricing, annual heating costs reached $463,000.**

Sea Water Heat Pump Project

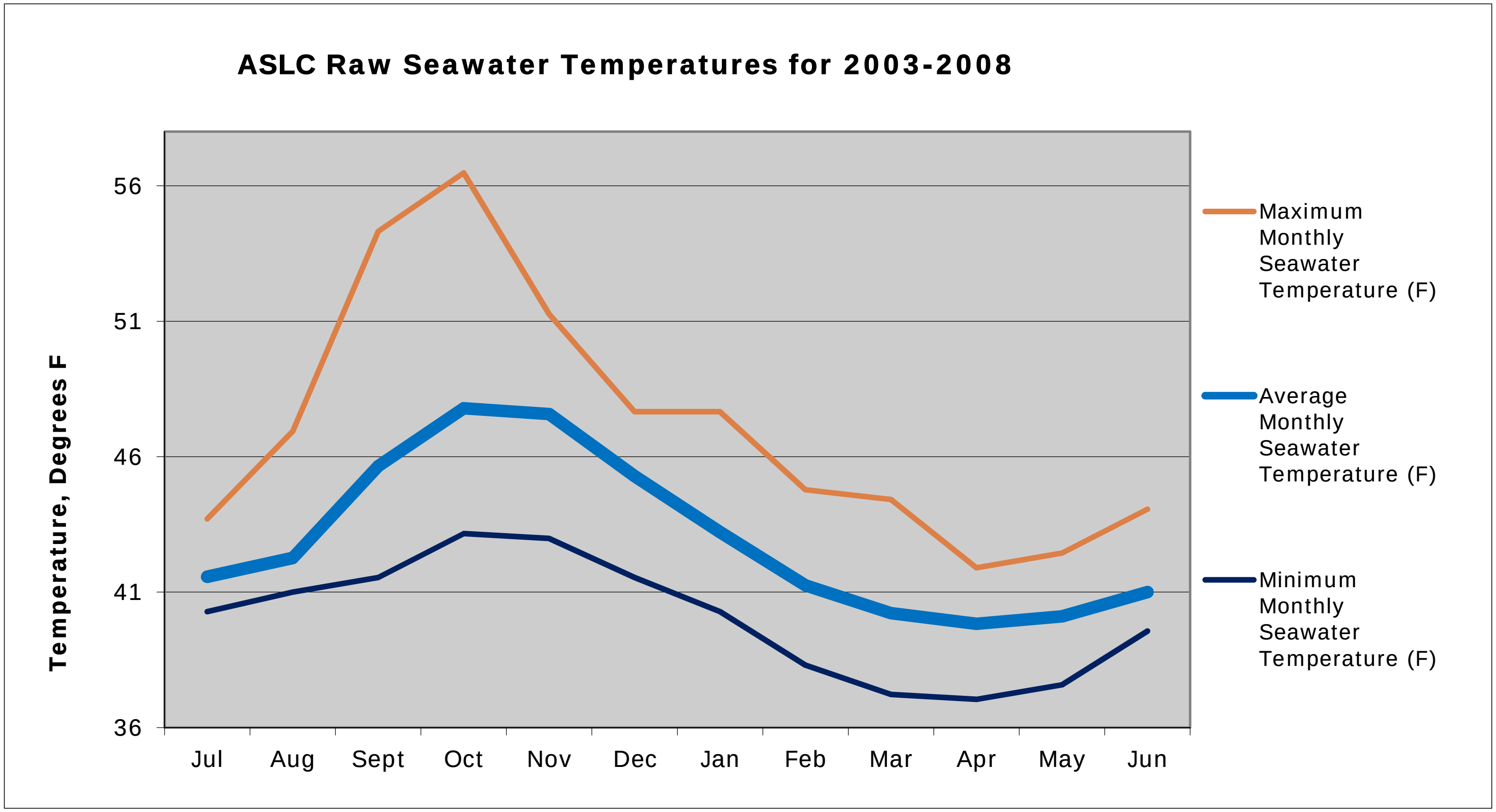


Resurrection Bay is very deep body of water – 900+ ft in large bathtub area

Bay is facing due south, receives tremendous solar gain thru summer

Bay holds heat because it is not flushed out by ocean currents; tides are mild; some cooling from glaciers and rivers that drain into Bay

Seward Sea Water Heat Resource



Storage of solar heat in Resurrection Bay = year round usable heat resource

Sea Water Heat Pump Project

Summary of Partnerships with Strong Support

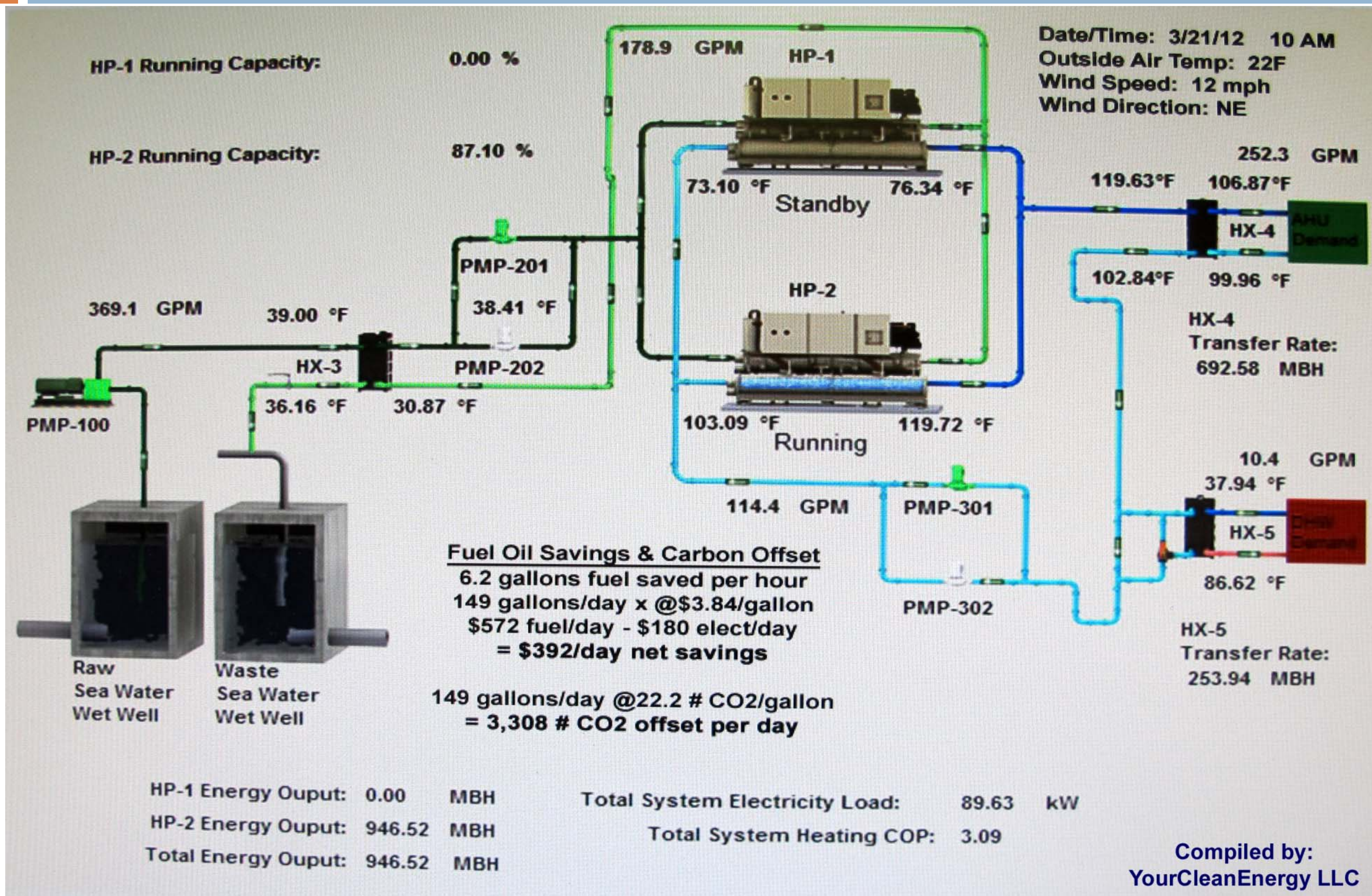
- **City of Seward –** looking to reduce future cost of heating for downtown district
- **Kenai Fjords National Park –** looking to reduce cost of heating for future visitor center and administration building
- **Alutiiq Pride Shellfish Hatchery –** also has an existing seawater intake available
- **UAF School of Fisheries & Ocean Sciences - Seward Marine Center –** also has existing seawater intake available

Financial Evaluation - Projected

CAPITAL COST: ($713,300 Grant + $120,000 Match)	**$ 833,300**
ANNUAL COST FOR GLYCOL PUMPING:	**$ 26,000**
ANNUAL COST FOR HEAT PUMP ELECTRICITY:	**$ 63,800**
ANNUAL COST FOR O&M:	**$ 12,000**
ANNUAL VALUE OF HEATING OIL SAVED:	**$ 192,000**
NET PRESENT WORTH WITH 20 YR LIFE CYCLE:	**$ 1,500,000**
YEARS TO PAYBACK INVESTMENT:	**8.5 YEARS**
ANNUAL CO2 PRODUCTION AVOIDED:	**1.3 million LBS CO2**

- **Electricity cost = start at $0.104/kwh with 4% per year escalation**
- **Heating oil cost = start at $3.84 /gallon with 6% per year escalation**
- **System running with slab heat connected & heat recovery installed**

Overall System Operator Screen



Actual Installation – Heat Pumps

photo by YourCleanEnergy LLC 12/8/12 Darryl, Tara, Andy

Two 90-Ton Heat Pumps – One or Two Heat Pump Operation

Actual Installation – Sea Water HX

Transfers Heat From Sea Water Into a Glycol Loop That Then Passes Through Heat Pumps

Actual Installation – Loop Pumps

High-Efficiency Circulation Pumps Move Glycol and Water Through the Heat Pumps

Actual Installation – Air Handler HX

Heat Pumps Warm Up Water Loop to 120°F – This Heat is Then Transferred to Air Handler Loop

Actual Install – Domestic Hot Water HX

City Water Entering at 45°F is Pre-Heated Up To 100°F With a Side Loop From Heat Pumps

Actual Installation – Motor Control Center

All Electricity Used For Heat Pumps, Circulation Pumps, and Controls is Supplied by One MCC

System Performance – Winter 2012/13

- Oil boilers turned off December 8, 2013 when main slab heat loop connected to heat pump system

  Net monthly savings of over **$18,000 per month** over previous year in months of January, February & March 2013 (including electricity for HPs).

Total System COP now within 4% of design expectation of 3.0

January	2013	COP = 2.88
February	2013	COP = 2.95
March	2013	COP = 2.92
April	2013	COP = 3.15

Lessons Learned – Winter 2011/12

- Heat pumps operate most efficiently when **fully loaded**
- **Sidewalk snow melt** is a large heat load that was added to heat pump system for winter 2012/13. Four more outdoor slabs will be added for next winter, this will increase system COP further
- Existing oil boilers are now **too large and expensive** to hybridize with heat pumps
- Original **HVAC controls** for air handlers and boilers require upgrades to increase benefit of low temperature heat from heat pumps

Project Tasks & Timeline

- **Final Design** was completed by YourCleanEnergy on November 30, 2010
- **Equipment installation** - March - June 2011
- **Commissioning/start up** - July 2011 – April 2012
- **Testing & Data Monitoring** – Heating Seasons of 2011/2012 and 2012/2013
- **Connect Main Pavement Snow Melt To Heat Pumps And Install Heat Recovery System** – December 8 2012
- **Install heat recovery system and additional four outdoor slabs** - by fall of 2013

Project Status

- Construction completed July 2011, testing and commissioning phase complete by May 2013.
- Alaska SeaLife Center is now securing additional funding to improve the base sea water heat pump system:
  - install **heat recovery system** that uses waste heat from exhaust fans to pre-heat glycol before entering heat pumps; will increase COP, and the investment will payback in less than 3 years
  - **Connect additional four outdoor slabs** to heat pump system so that further reductions in oil usage will occur in shoulder seasons

Seawater Heat Pumps

Non Res. Bldgs and District Heating/Cooling Systems

- Heat source
  - Seawater (the Gulf Stream, 4-8°C) – direct or indirect system design
- Heating and cooling
  - Space heating
  - Hot water heating
  - Heating of ventilation air
  - Cooling – free cooling or chiller operation
- COP – heat source – Norwegian market
  - Suitable temperature level – excellent as heat source and heat sink (free cooling)
  - Requires adequate heat source system in order to avoid fouling, freezing and corrosion
  - Several hundred large installations in Norway

Royal Garden Hotel, Tr.heim – 700 kW

Fornebu – 12 (25) MW

What is District Heating?

District heating is a convenient way to distribute renewable energy heat and waste heat to buildings for space heating, domestic hot water heating, snow melting, and swimming pool heating.

The fundamental idea behind modern district heating is to reduce cost of heat and recycle surplus heat which otherwise would be wasted from electricity production, and from different industrial processes, including refrigeration (cold storage).

District heating can make efficient use of renewable low temp heat from sea water.

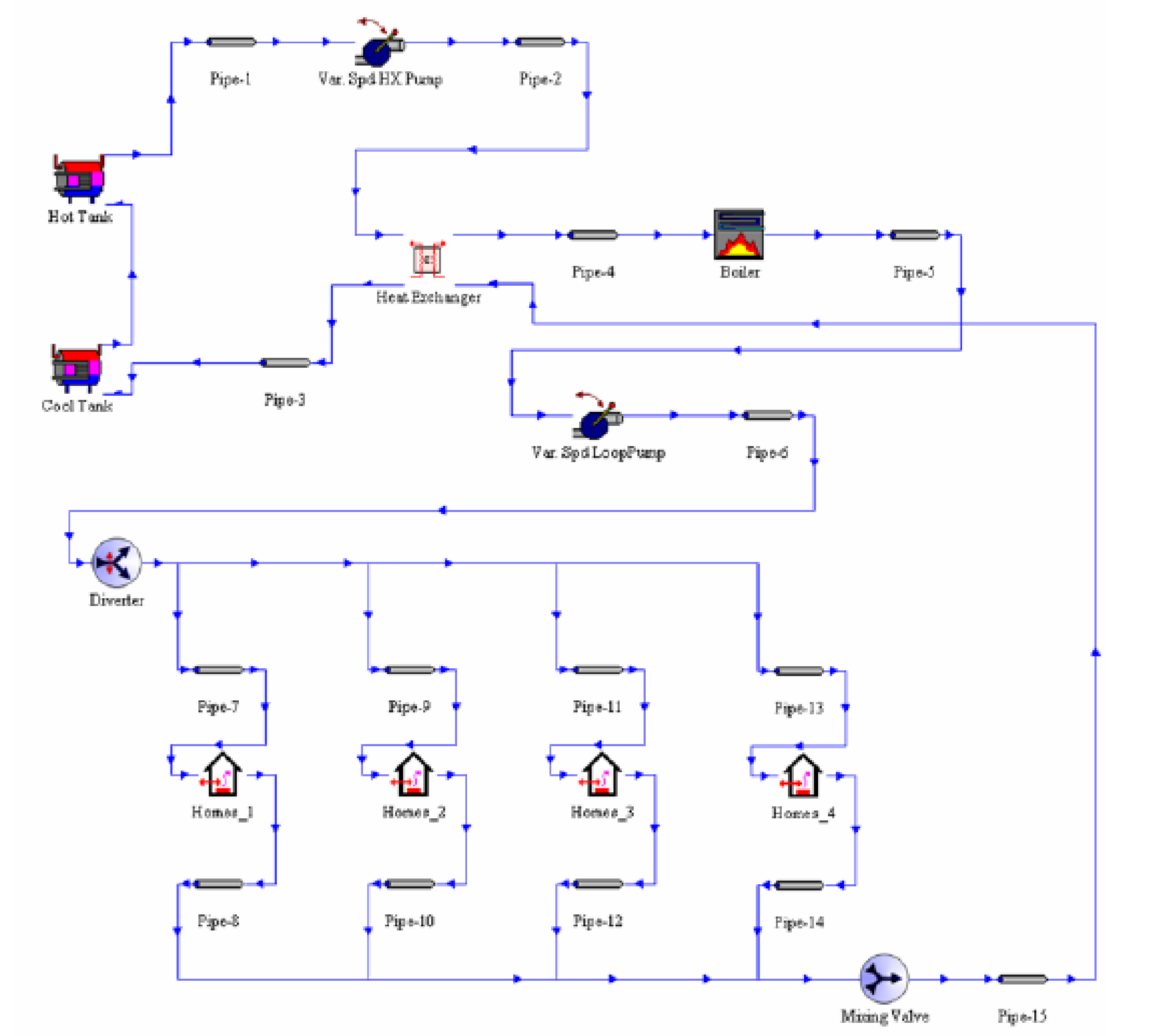


Figure 1: District Loop Layer in TRNSYS

Primary benefits of locally owned district heating:

- avoid importation of heating oil and its escalating costs (6 to 10% per year expected)

- price stability (cost of heat tied mostly to cost of hydro electricity

- produce heat at lower cost than heating oil, electric heat, or biomass for the extended future

- Properties along the district loop will increase in value, densification will occur, tax revenues increase

- environmental savings – minimal CO2 and polluting emissions, reduced fuel storage and spills

Sea Water Heat Pumps For District Heating

- Sea Water Heat Pumps provide affordable, reliable, and safe alternative to burning organic carbon
- Sea Water Heat Pump technology and systems are proven in northern climates, with many examples to learn from
- Sea Water Heat Pumps allow district heating at low to medium temperatures, without the high energy losses or dangers of steam lines
- Low to medium temperature heat distribution propels 1)investments in building envelope efficiency, and; 2)installation of low temperature heat distribution (radiant floor, duct coils for air handlers, outdoor pavement heating, domestic hot water heating, swimming pool heating)

Willoughby District – Downtown Juneau

SEA WATER HEAT PUMP / DISTRICT HEATING PROJECTS TO CONSIDER FOR JUNEAU

Start with small district - new or existing large public buildings:

-**Centennial Hall, Foodland Complex, etc.**

-**Integrate the sea water district heating concept into planning:**

-**Engineering evaluation of viable options**

-**Downtown heating district served by single heat pump station**

Alaska SeaLife Center
windows to the sea

Sea Water Heat Pump Project

Andy Baker, PE YourCleanEnergy LLC

Your Questions About This Project?

Please visit your Alaska SeaLife Center in 2013