GEOTHERMAL DISTRICT HEATING

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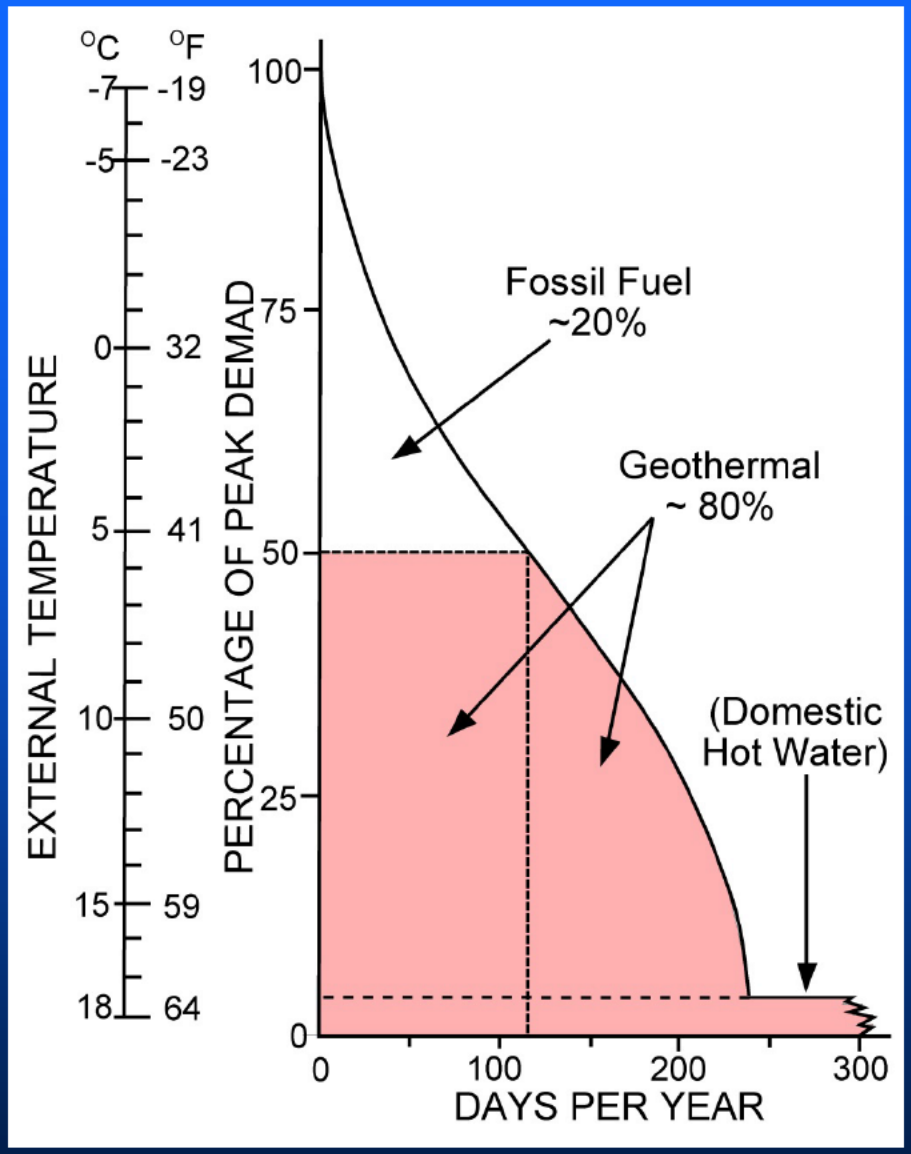
GEOTHERMAL DISTRICT HEATING/COOLING

Geothermal resource supplying thermal energy to a group of buildings, providing:

- Space heating and cooling
- Domestic hot water heating
- Industrial process heat

Could be a hybrid system augmented by:

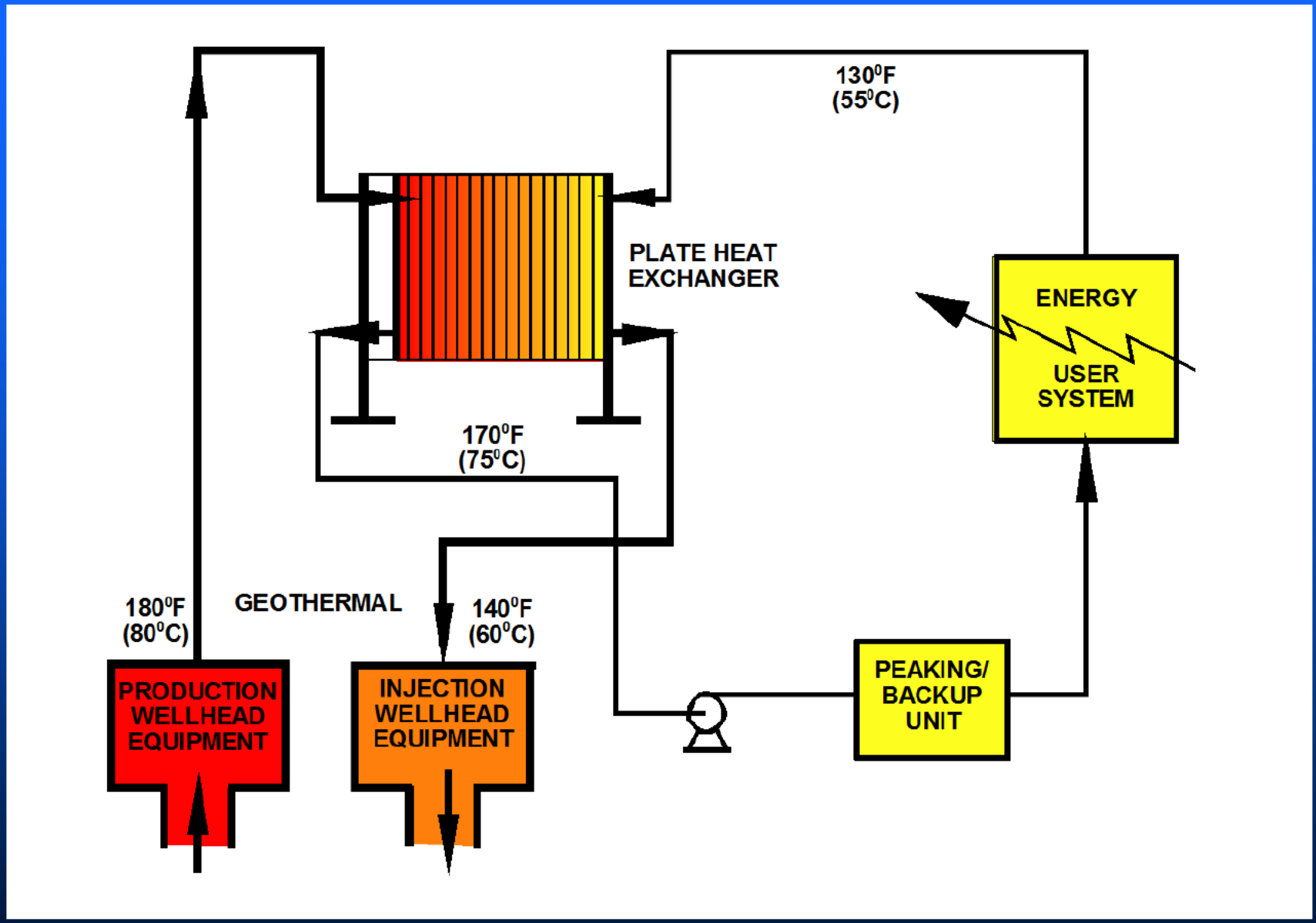
- Heat Pump to boost temperature
- Conventional boiler for peaking



Meeting peak demand with fossil fuel

MAJOR SYSTEM COMPONENTS

1. Heat Production – well field(s)
   - Production wells
   - Injection wells
   - Peaking station
2. Transmission/distribution system
   - Delivery of heat to consumers (water or steam)
3. Central pumping station, and in-building equipment
   - Energy or flow meters
   - Heat Exchangers
   - Circulation pumps



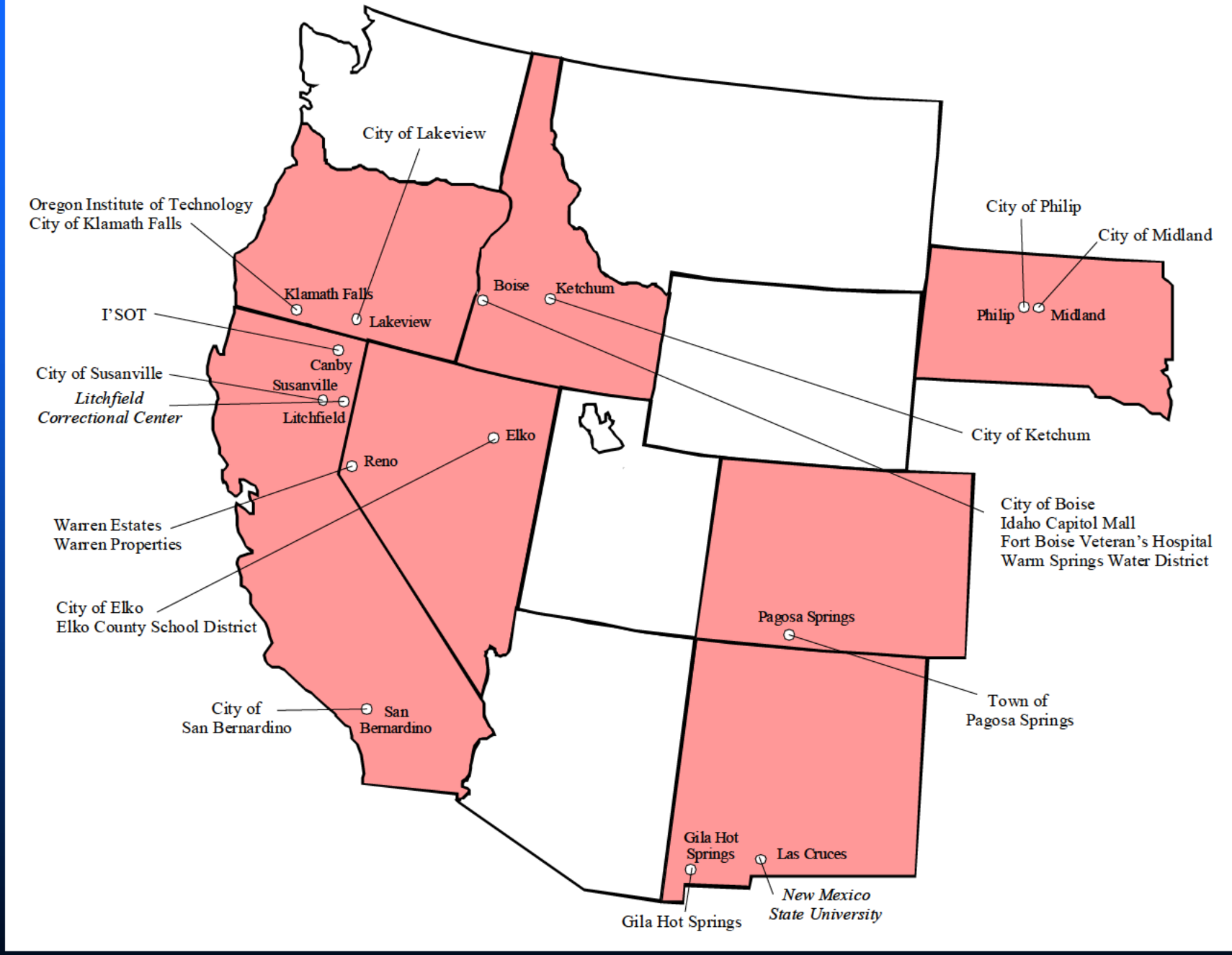
Major components of a geothermal district heating system

U.S. GEOTHERMAL DISTRICT HEATING SYSTEMS

- 19+ systems in the U.S.
- 138^{o} to 218^{o}F (59^{o} to 103^{o}C)
- Peak flow of 63 to 4,000 gpm (4 to 253 L/s)
- Installed capacity: 0.2 to 31 MWt
- Annual energy use: 2.0 to 75 billion Btu/yr (2.1 to 79 TJ/yr or 0.6 to 22 GWh/yr)
- Total
  - ~82 MWt
  - ~800 billion Btu/yr or 840 TJ/yr (235 GWh/yr)
  - ~45 miles (72 km) of pipelines

U.S. Geothermal District Heating Systems

- Boise Warm Springs Water District – 1892
- Ketchum, Idaho – 1929
- Oregon Institute of Technology – 1962
- Midland, SD – 1964
- Klamath Falls – 1981
- Elko, NV - 1982
- Remaining < 30 years old
- Latest: Canby, CA 2003; Lakeview, OR 2014

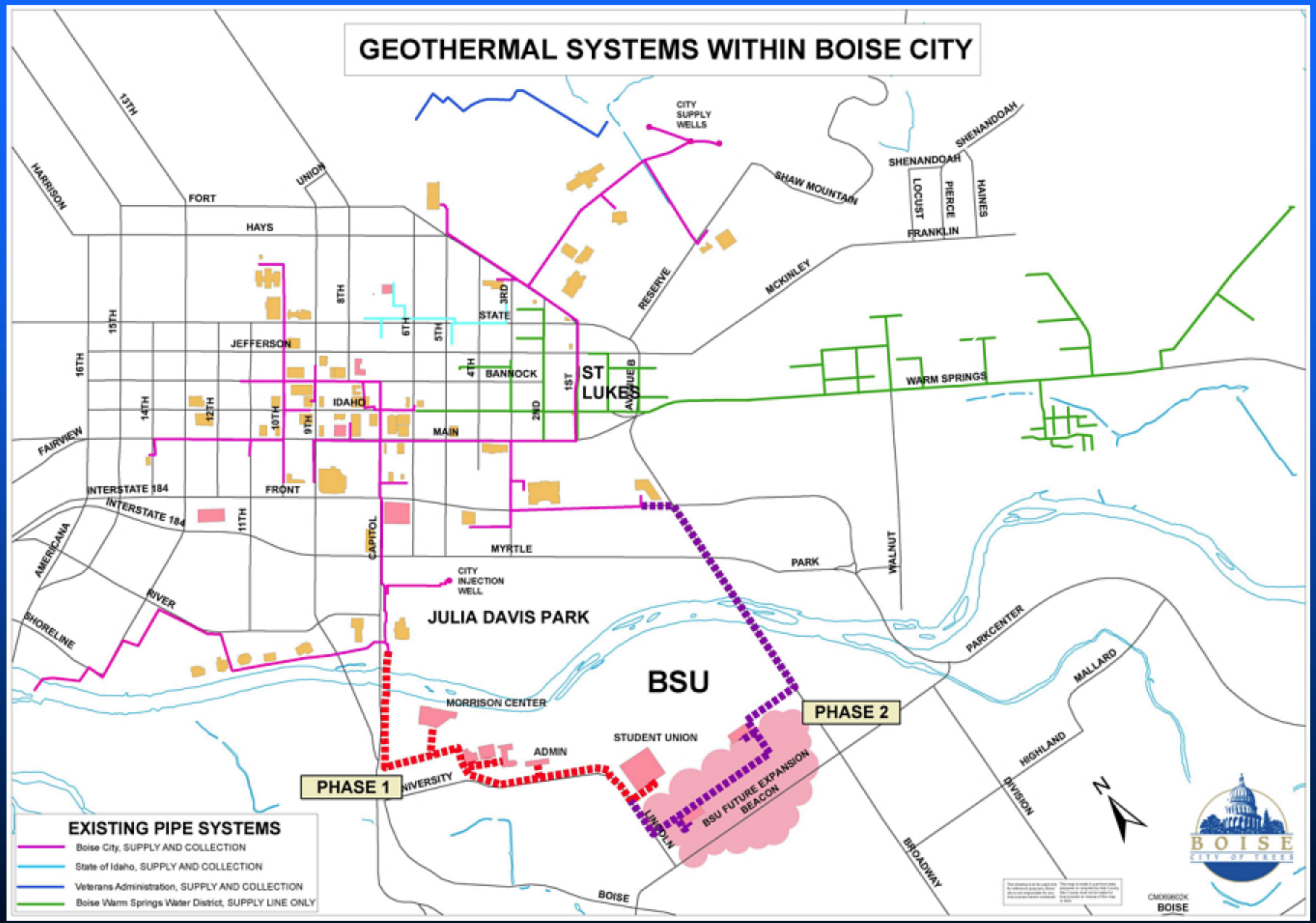

City of Lakeview
Oregon Institute of Technology
City of Klamath Falls
Klamath Falls
Lakeview
I'SOT
Canby
City of Susanville
Susanville
Litchfield
Litchfield
Correctional Center
Reno
Elko
Warren Estates
Warren Properties
City of Elko
Elko County School District
City of
San Bernardino
San
Bernardino
Boise
Ketchum
City of Ketchum
City of Philip
City of Midland
Philip
Midland
City of Boise
Idaho Capitol Mall
Fort Boise Veteran's Hospital
Warm Springs Water District
Pagosa Springs
Town of
Pagosa Springs
Gila Hot
Springs
Las Cruces
New Mexico
State University
Gila Hot Springs

CITY OF BOISE SYSTEM

- Warm Springs Avenue system installed in 1892, heating 250 large residences – still in operation.
- City geothermal district heating system began operation in 1983, using a $6.76 million PON grant from USDOE.
- Geothermal fluid at 170°F (77°C) pumped from the reservoir under the city

CITY OF BOISE SYSTEM (2)

- System now serves 81 buildings of 3.8 million ft^2 (353,000 m^2) – 22.2 MWt max.
- Circulates > 190 million gallons thru 13 miles of pipelines (720 tonnes @ 21 km)
- In 2012 the system was extended across the Boise River to Boise State University, heating 600,000 ft^2 (56,000 m^2) of building space at a cost of $3.4 million – completed in 2015.


GEOTHERMAL SYSTEMS WITHIN BOISE CITY
CITY SUPPLY WELLS
SHENANDOAH
SHAW MOUNTAIN
LOCUST
PIERCE
HAINES
FRANKLIN
RESERVE
MCKINLEY
WARM SPRINGS
ST LUKES
AVENUE B
13TH
HARRISON
FORT
UNION
HAYS
15TH
8TH
6TH
5TH
3RD
STATE
JEFFERSON
16TH
14TH
12TH
10TH
9TH
4TH
BANNOCK
1ST
2ND
IDAHO
MAIN
FAIRVIEW
INTERSTATE 184
FRONT
11TH
CAPITOL
MYRTLE
PARK
WALNUT
AMERICANA
RIVER
BHORELINE
CITY INJECTION WELL
JULIA DAVIS PARK
BSU
MORRISON CENTER
ADMIN
STUDENT UNION
PHASE 1
PHASE 2
BSU FUTURE EXPANSION BEACON
PARKCENTER
MALLARD
HIGHLAND
DIVISION
BROADWAY
BOISE
N
EXISTING PIPE SYSTEMS
Boise City, SUPPLY AND COLLECTION
State of Idaho, SUPPLY AND COLLECTION
Veterans Administration, SUPPLY AND COLLECTION
Boise Warm Springs Water District, SUPPLY LINE ONLY
BOISE
CITY OF TREES

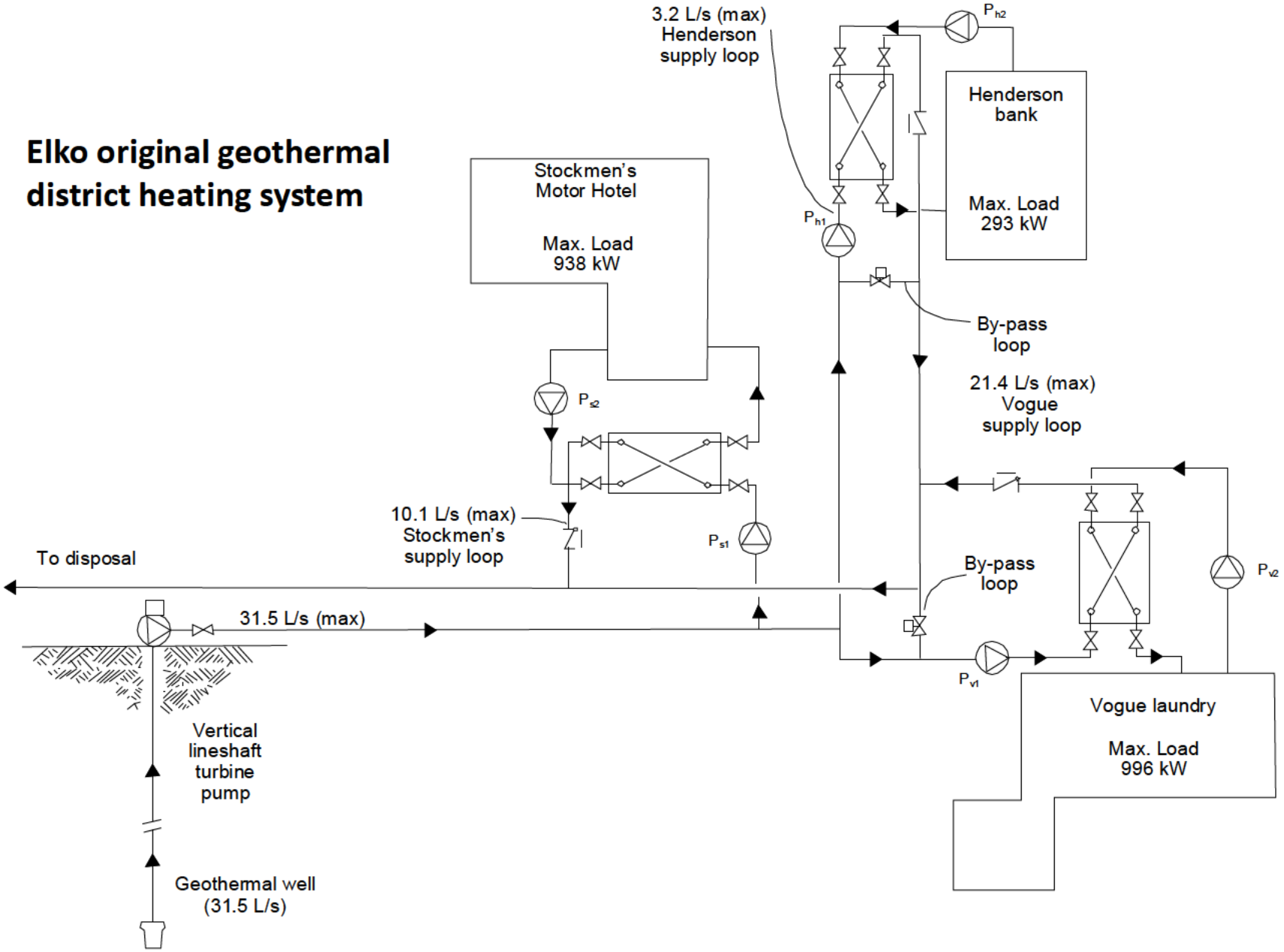
Elko, Nevada

- District Heating since 1982
- Serves 19 customers (residential & commercial)
- 80 million gallons/yr (0.3 million tonnes/yr)
- 178^{o}F (81^{o}C) fluid
- Space heating & domestic hot water heating (~300,000 ft^2 – 28,000 m^2)
- Snow and ice melting on sidewalks
- Commercial laundry
- Sewage treatment plant – digester heating
- Industrial park – using return water

Elko, Nevada (2)

- Two-pipe system – open loop
  - Insulated supply
  - Uninsulated return
- Supply lines 8-inch (20-cm) diameter
  - Some 6 and 4 inch (15 and 10 cm)
  - AC (transite), epoxy-lined, polyurethane insulation and AC outer jacket
  - Return line – uninsulated AC
  - 9,358 feet (2,850 m) of distribution line

Elko original geothermal district heating system



Elko, Nevada (3)

- Disposal in 1.5 acre (0.6 ha) cooling pond, then discharged to wetlands area adjacent to river (quality good – 605 ppm)
- New industrial park uses waste water at 120 to 130°F (50 to 55°C) – floor heating and snow melting – irrigating lawn (heat dissipated under parking lot)
- $1.4 million – design & construction - $827,000 provided by USDOE – PON
- Charged $1.50/1000 gallons ($0.39/1000 L) ~ 2.1 cents/kWh ~ 30% of equivalent for natural gas

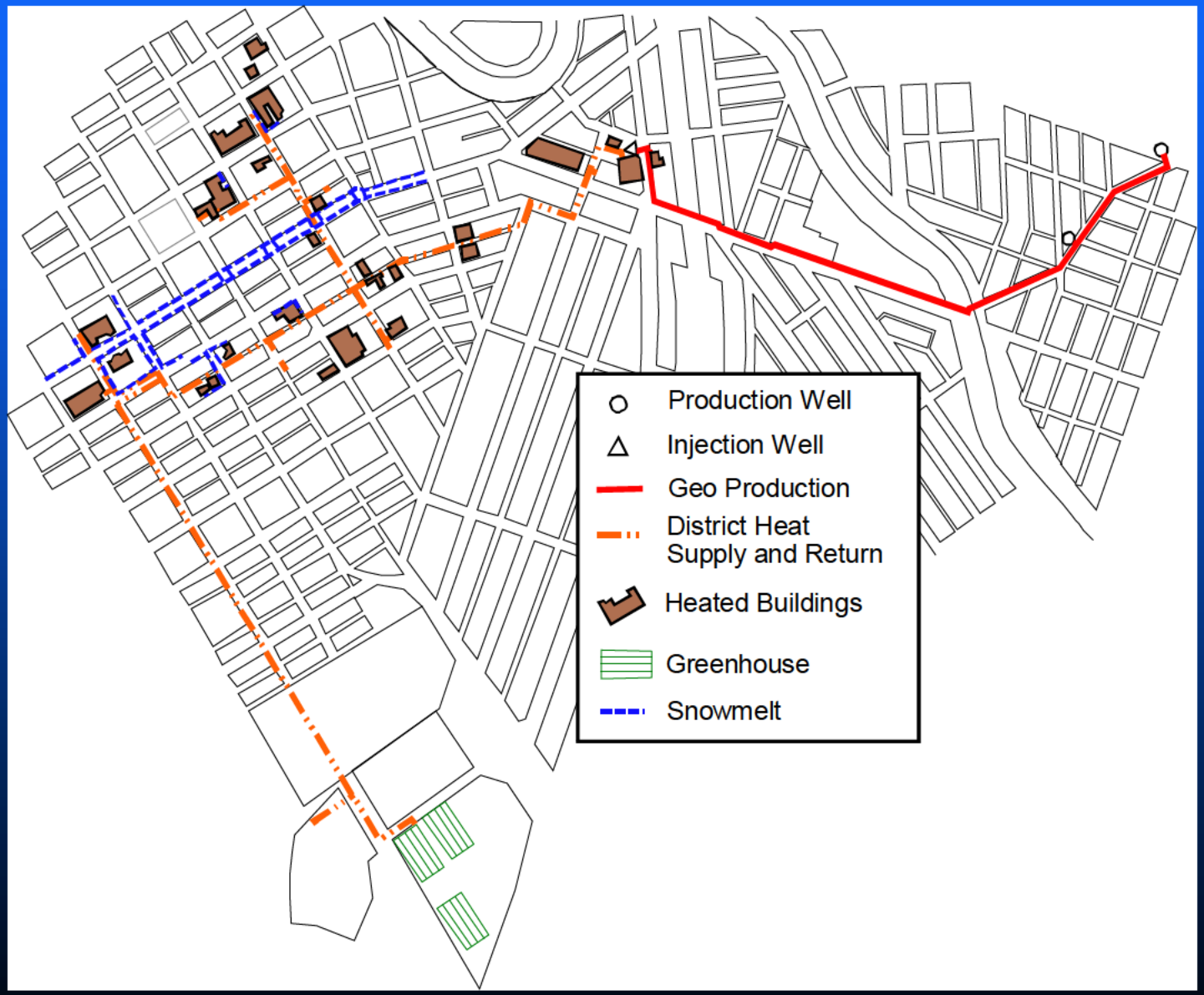
KLAMATH FALLS DISTRICT HEATING SYSTEM

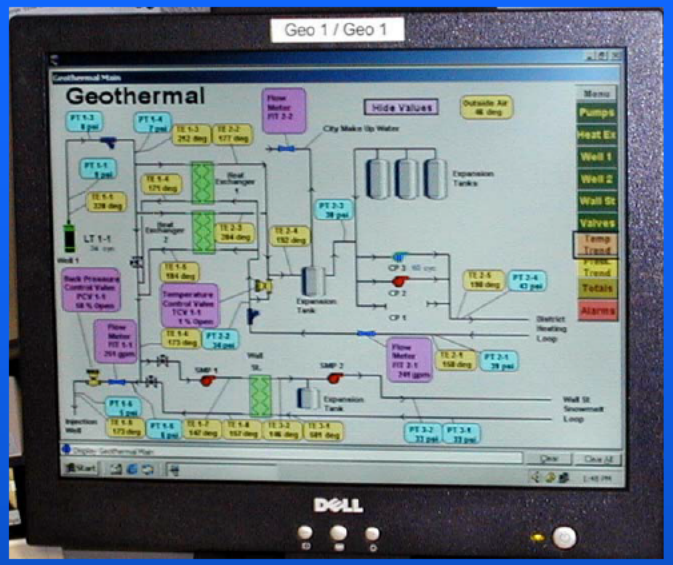
- Established in 1977 – feasibility study
- USDOE – PON grant
  - $2.58 million – 65% federal funds - 1978
- Built 1979-1980 - Operated by City of Klamath Falls
- Two wells – 367/900 ft (112/274 m)
  - 219/212°F (104/100°C)
  - 720/770 gpm (45/49 L/s) – max
- Supply:
  - Pipeline 4,040 ft (1,231 m) – 8 in. (20 cm) preinsulated steel
  - 2 plate heat exchangers each 10 million Btu/hr (10.5 GJ/hr)
  - Secondary loop – out at 180°F (82°C) in at 140°F (60°C)
  - Closed loop – 12,680 ft (3,865 m) @ max. 1,200 gpm (76 L/s)
  - Injection well 1,235 ft. (376 m) deep – 2,500 ft (763 m) from production wells

KLAMATH FALLS DISTRICT HEATING SYSTEM (2)

- Present – 24 buildings including the new County Gov't Center – 400,000 sq. ft. total
- Snow melt system – 150,000 ft^2 (14,000 m^2) – 2nd HE for snow melting
- Brewery – micro-brews
- Greenhouse – tree seedlings – 4 acres (1.6 ha)
- 8.5 MWt capacity (29 MBtu/hr – 30.5 GJ/hr)
  - 3.5 MWt utilized
  - 12 million Btu/h (13 GJ/h) – 60% of max. capacity
  - ~ ΔT 40°F (22°C) on secondary loop

KLAMATH FALLS DISTRICT HEATING SYSTEM





City district heating system

OTHER KLAMATH FALLS GEOTHERMAL USES ON THE DISTRICT HEATING SYSTEM

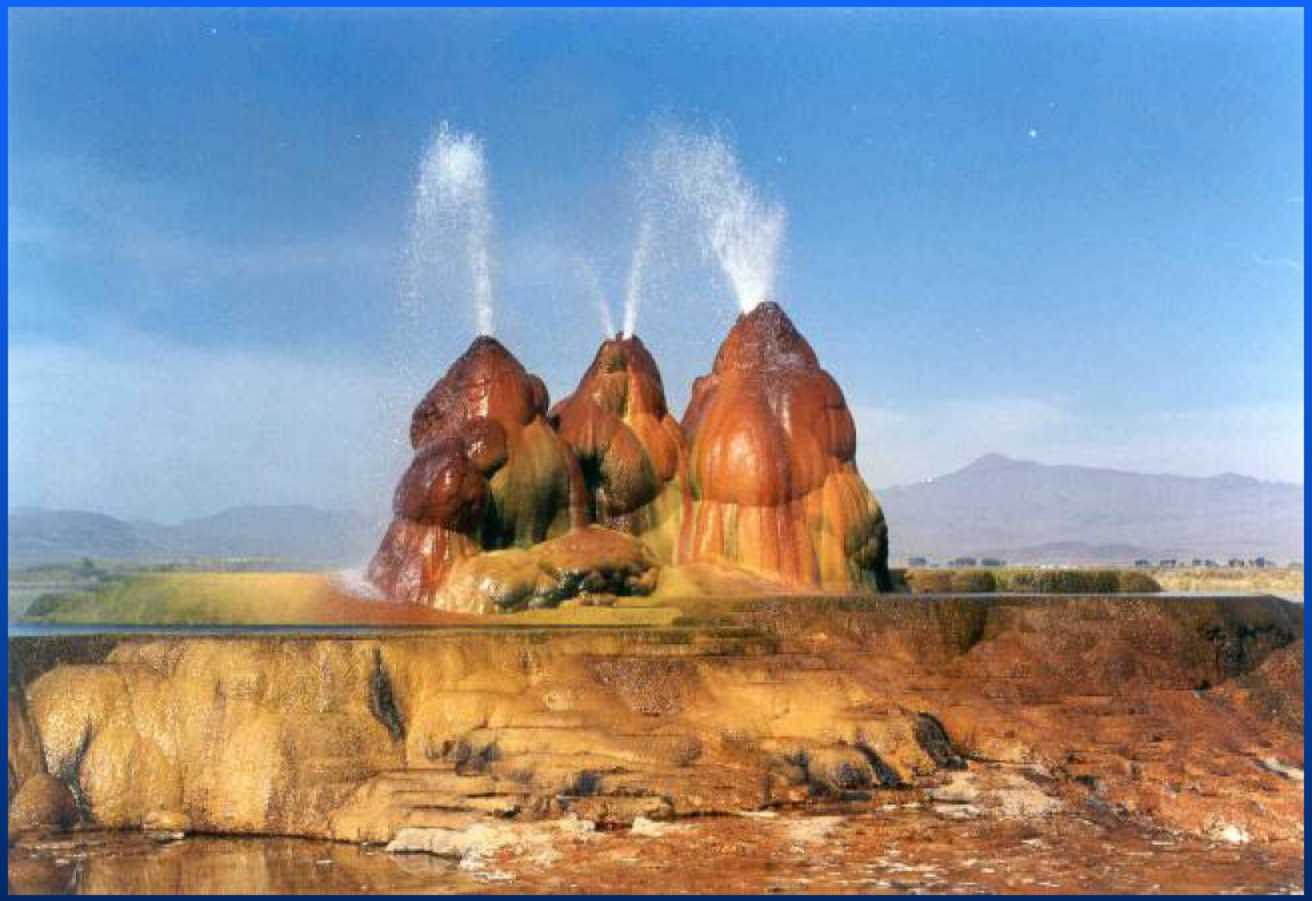
IFA Nursery – 1.6 ha (4 acres) – trees seedlings

KLAMATH BASIN BREWING COMPANY
Klamath Falls, Oregon

Klamath Falls snow melting system

NEW TRENDS

- COMBINED HEAT AND POWER PLANTS
  - Low temperature resources used for binary power production and cascaded for direct use
  - Temperatures as low as 208^{o}F (98^{o}C) are being used (Chena HS at 165^{o}F (74^{o}C))
  - Makes efficient use of the resources
  - Improves economics
  - Increases employment
  - Oregon Inst. of Tech. and Chena Hot Springs



THANK YOU