DIRECT UTILIZATION OF GEOTHERMAL ENERGY 2010 WORLDWIDE REVIEW

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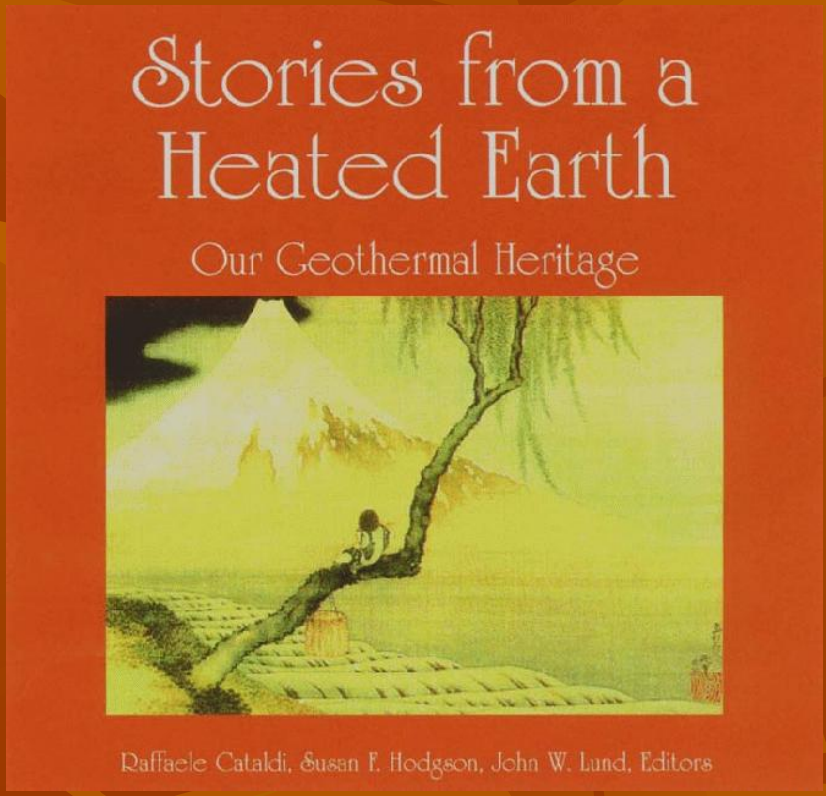
INTRODUCTION

- Direct-use – oldest and most common form of using geothermal energy
- Documented in ***"Stories from a Heat Earth – Our Geothermal Heritage"*** 1999 (Cataldi, Hodgson, Lund, ed.)



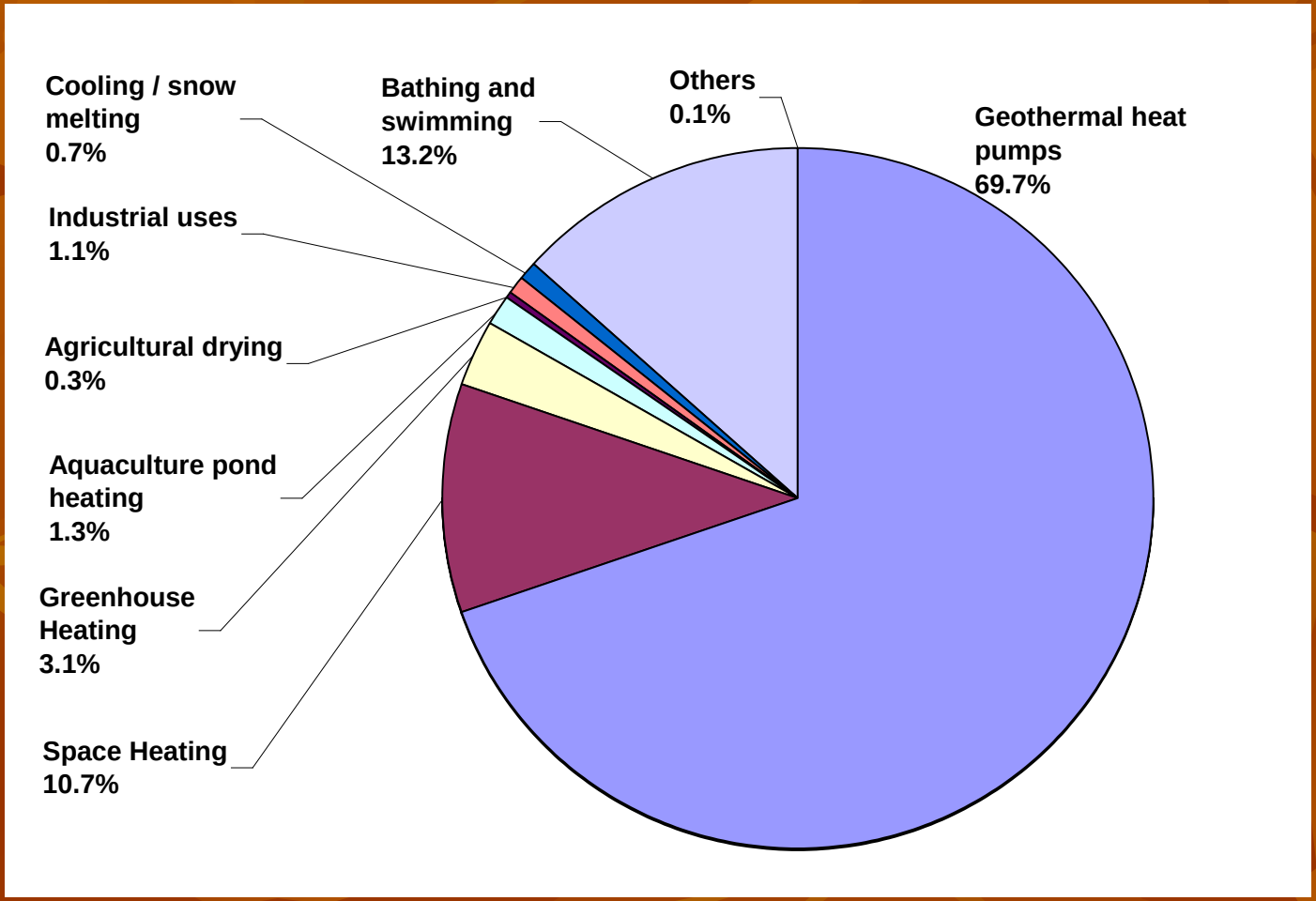
INTRODUCTION 2

- Direct-use includes:
  - Space and district heating
  - Greenhouse heating
  - Aquaculture pond and raceway heating
  - Industrial applications
  - Agricultural drying
  - Snow melting and cooling
  - Bathing and swimming (spas and balneology)
  - Geothermal (ground-source) heat pumps

INTRODUCTION 3

- Data from country update papers
  - 70 papers received
  - 66 reported some geothermal direct-use
  - 12 other countries added from other sources
  - Total of 78 countries
  - 6 new countries added from WGC2005

INSTALLED CAPACITY (MWt)



SPACE HEATING

- 35 countries
- 24% increase in capacity and 14% increase in annual energy use
- 85% due to district heating – 24 countries

GREENHOUSES AND COVERED GROUND HEATING

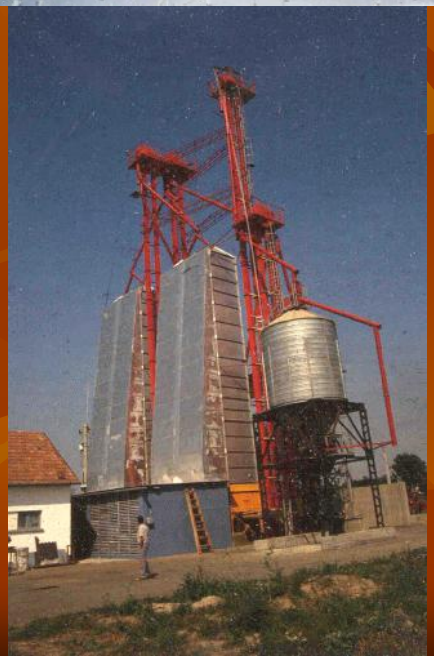
- 34 countries
- Increased 10% in capacity and 13% in energy use since WGC2005.
- Main crops: vegetables and flowers; also tree seedlings and fruit
- Approximately 1,163 ha worldwide

AQUACULTURE POND AND RACEWAY HEATING

- 22 countries
- Increased 6% in capacity and 5% in annual energy use from WGC2005.
- Main crops: Tilapia, but also tropical fish, lobsters, shrimp, prawns and alligators
- Approximately 47,600 tonnes harvested annually.

AGRICULTURAL CROP DRYING

- 14 countries
- A decrease in use from WGC2005 – mainly due to closing of plants in the USA
- Crops being dried: grains, alfalfa, vegetables, timber, coconut meat, and fruit.



INDUSTRIAL PROCESS HEAT

- 14 countries
- Increased 10% in capacity and 8% in annual energy use since WGC2005
- Products produced: concrete blocks, milk, chemicals, pulp and paper, CO_2, bottling of mineral water.

SNOW MELTING AND SPACE COOLING

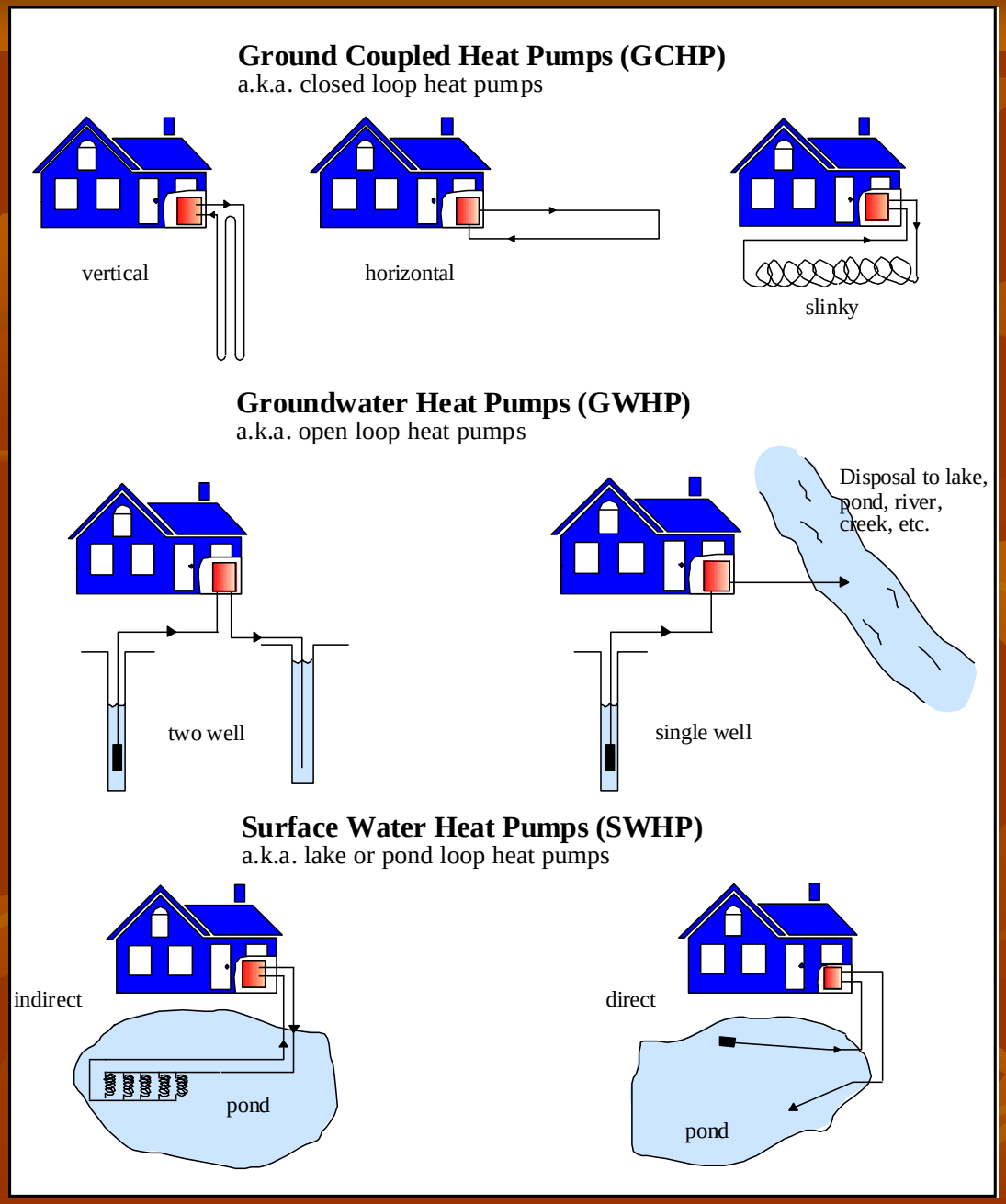
- Limited applications
- Snow melting in Iceland, Japan, Argentina, USA, Switzerland (approx. 2 million m^2)
- Space cooling in Japan, Bulgaria, USA, Switzerland, Slovenia
- Geothermal heat pumps not included

BATHING AND SWIMMING (SPAS & BALNEOLOGY)

- Difficult to obtain good data
- Many cases data had to be estimated
- 67 countries + 4 others known
- Increase of 24% in capacity and 31% in annual energy use from WGC2010

GEOTHERMAL HEAT PUMPS

- Largest installed capacity and energy use – growing at a rate of 18 – 20%/year
- Most installations are in North America, Europe and China
- 43 countries reported use – up from 33 in 2005 and 26 in 2000
- Approx. 3 million units installed (12 kW equivalent size) – 2.3 x 2005, and 4.6 x 2000
- 2,000 to 6,000 full-load hours/year
- Average COP = 3.5



Geothermal heat pump installations

OTHERS

- 7 countries
- Includes
  - Animal farming
  - Spirulina cultivation
  - Desalination
  - Sterilization of bottles

ASIAN PACIFIC COUNTRIES

- Australia
  - Aquaculture, Bathing and Swimming, Geothermal Heat Pumps
  - 33.3 MWt
- China
  - District and Space Heating, Greenhouses, Aquaculture, Industrial, Bathing and Swimming, Geothermal Heat Pumps
  - 8,898 MWt
  - Geothermal district heating in Tianjin utilizing GHP water is now servicing some 1 million saving 1.17 million tons of standard coal equivalent and reducing 2.78 million tons of CO2 emissions.
- India
  - Bathing and Swimming
  - 265 MWt

ASIAN PACIFIC COUNTRIES 2

- Indonesia
  - Bathing and Swimming
  - 2.3 MWt
  - A paper by Surana et al. (2010) indicates additional direct use installations in the country, including bathing and swimming, mushroom growing, palm sugar production, copra and cocoa drying, aquaculture, and space heating.
- Japan
  - The direct use of medium- and low-enthalpy geothermal water is mainly located in the areas around the highenthalpy geothermal area, where hot spring resources are abundant
  - Space Heating, Greenhouses, Aquaculture, Industrial, Air Conditioning and Snow Melting, Bathing and Swimming, and Geothermal Heat Pumps
  - 2099.5 MWt

ASIAN PACIFIC COUNTRIES 3

- Korea (South)
  - District and Space heating, Greenhouses, Bathing and Swimming, and Geothermal Heat Pumps
  - 229.3 MWt
- Mongolia
  - Space Heating, Greenhouses, Bathing and Swimming
  - 6.8 MWt
- New Zealand
  - The Kawerau facility, pulp and paper manufacturing, now accounts for 56% of the national geothermal direct-use. It is also the largest industrial use in the world and is set to expand further to adjacent industrial users.
  - Space Heating, Greenhouses, Aquaculture, Industrial, Bathing and Swimming, Other, and Geothermal Heat Pumps
  - 393 MWt

ASIAN PACIFIC COUNTRIES 4

- Papua New Guinea
  - On New Britain Island, heat is used to boil megpod eggs and the megapod (local fowl) use the hot ground to incubate their eggs, which are harvested by the locals
  - Bathing and Swimming
  - 0.1 MWt
- Philippines
  - Agricultural Drying and Swimming and Swimming and Bathing
  - 3.3 MWt
- Thailand
  - Agricultural Drying and Swimming and Bathing
  - 2.54 MWt
- Vietnam
  - Agricultural Drying, Industrial, Bathing and Swimming
  - 31.2 MWt

ENERGY SAVINGS

- Replacing electricity (efficiency 0.35):
  - 308 million bbl of oil equivalent savings
  - 46 million TOE oil savings
  - 47 million TOE carbon savings
  - 148 million TOE CO_2 savings
  - 1 million TOE of SO_x savings
  - 0.3 million TOE of NO_x savings
- Equivalent to 3.6 days of worldwide oil use
- Replacing direct-heat (furnace) (efficiency 0.70) – thus, half of above figures

CONCLUSIONS

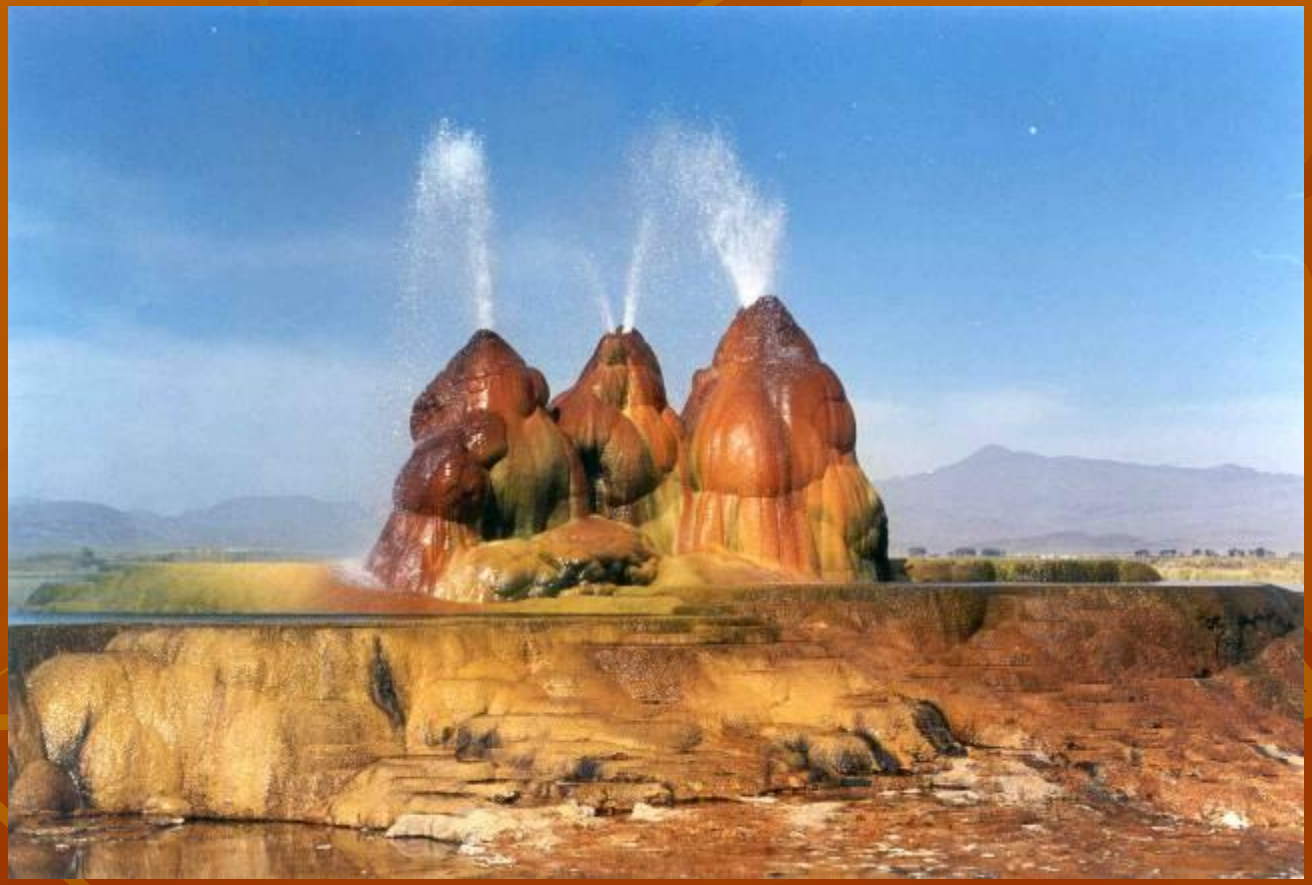
- Renewed interest in “green” and “renewable” energy sources
- Geothermal can make a major contribution to the world energy needs – direct-use growing at a rate of 10-12%/year since 2005
- However, “geothermal” is not well known and the benefits generally unknown – it needs to be promoted better

CONCLUSIONS 2

- Geothermal heat pumps are the fastest growing use of geothermal energy – available anywhere as it uses normal ground and ground-water temperatures for both heating and cooling.
- Low temperature combined heat and power plants using the binary cycle for power and cascading for space heating is gaining popularity – especially in Europe – maximizes the use of the resource and improves the economics of the project.

CONCLUSIONS 3

- The development and use of geothermal energy needs your help
  - To promote its use
  - To educate the public and decision makers in government and industry
  - To develop demonstration projects to show its simplicity and benefits
  - To encourage financial incentives for its development
  - To help minimize the risk of development to encourage investments
  - It is “green” and “sustainable”



THANK YOU