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#### Alternate Energy Sources and Their Impact

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## If technology is the problem

- We can blame technology.
- "I am innocent" we say. "Technology made me do it."

Is that Right?

## If technology is the problem

*Wrong!* • We can blame technology.

*Wrong!* • "I am innocent" we say. "Technology made me do it."

Wrong! • Or we say "I do not make policy."

That is passing the buck, following Pontius Pilot not Jesus.

## If technology is not the problem

• Then anything goes. Is that Right?

## If technology is not the problem

- Then anything goes. *Wrong!!!*
- 1 Cor. 23-26: "Everything is permissible but not everything is beneficial. Everything is permissible – but not everything is constructive. Nobody should seek his own good, but the good of others."
- Do our energy polices & choices seek the good of others?

### Technology is neither "The" solution nor "The" problem!

• We are instructed "love the Lord thy God... and ... thy neighbor."

- Is consuming fossil fuels that could shared with our neighbors and grandkids, "loving thy neighbor?"
- Will God hold us accountable for choices we make regarding energy?



## Rather than blame technology, we must accept that we make sinful technology choices



## The Geothermal Resource

Any location can provide energy if we drill deep enough...



**Direct use (heating)** 

The trick is having the right combination of heat, water, and permeability at reasonable depth

## Renewing of Geothermal Resources

- By volcanic eruptions
- Deep circulation of water
- Conduction

(~3TW) (~6TW) (10TW)



#### World Wide Energy Consumption: 16TW

### Magmatic Geothermal Resources

- Magmatic renewability is calculated by volume and frequency of volcanic eruptions.
- Magmatic resources are not expected to be economic in the foreseeable future (>2050?)



## Hydrothermal Geothermal Resources

- Deep circulation or hydrothermal resource renewability has been estimated by correlation of assessments of known hydrothermal resources to volcanic activity.\*
- Hydrothermal geothermal resources are economically competitive with fossil fuel depending on the grade of the resource.



\*Valgardur Stefansson, World Geothermal Congress 2005.

### Conduction Geothermal Resources

- Renewability of conduction resources is subject to direct measurement.
- The conductive flux is low.
- Thus energy must be extracted from stored heat.
- Conduction resources typically have insufficient permeability and/or porosity requiring an Engineered Geothermal System (EGS)
- Engineered Geothermal Resources are still in the development stage.



#### Hydrothermal Resource Utilization



## Sustainable Energy Production

- Sustainable development: "meeting the needs of the present without compromising the ability of future generations to meet their own needs ."\*
- 100 to 300 years is frequently used as a practical period for "future."
- Sustainable development is supposed to be founded on three pillars:
  - Environmental issues,
  - Economic issues, and
  - Social issues.

\*World commission on Environment and Development, 1987

#### Sustainable Geothermal Production

- Lifetime of geothermal activity around magmatic intrusions is 5,000 to 1,000,000 years.
- Since there is more heat in the rock than the water, what becomes depleted first is the pressure.
- Each resource has a sustainable production limit.
- While some geothermal resources have been over produced, no geothermal resource has been abandoned as a result.
- Over produced recourses recover rapidly.
- Re-injection is the key.



## Energy Return on Investment



### Parasitic Power







#### Capital Energy Investment vs. Life Cycle Energy Return



## Engineered Geothermal Systems: from concept to reality

- Increase flow through reservoir without premature cool water break through
- Improve downhole mapping of reservoir
- Manage water leakage
- Increase temperature limits on downhole equipment
- Reduce drilling costs
- Demonstrate the technology



#### So what is the good we ought to do?

- Accept responsibility
- Informed decisions
- Rational decisions
- Based on balanced evaluations
  considering the tradeoff's & all issues
- Unbiased decisions
- Consideration for
  - the disadvantaged
  - future generations
  - the environment

## Is that Biblical?

Responsible, Informed, Rational, Balanced, Unbiased, & Compassionate

- *"for all have sinned"* Rom 3:23
- "Anyone, then, who knows the good he ought to do and doesn't do it sins" James 4:17
- "Now the Brereans were of more noble character than the Thessalonians, for they received the message with great eagerness and examined the Scriptures every day to see if what Paul said was true." Acts 17:11

- *"always be prepared to give an answer"* 1 Pet 3
- *"were pleased to make a contribution for the poor"* Rom 15:26
- "If you show special attention to the man wearing fine clothes and say 'Here's a good seat for you,' but say to the poor man, 'You stand there'" James 2:3
- "by doing good you should silence the talk of foolish men" 1 Pet 2:15

- Low land usage
- Minimal water usage
- Minimal emissions
- Minimal green house gases emissions
- Minimal waste
- Easy reclamation
- Risks & impacts understood
- Low resource demand

- High availability 24-7-365
- Good option for developing countries
- High Surety (reliability, security, safety, & sustainability)
- Other considerations
  - Time to implement
  - Energy return on energy investment

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Minimal emissions including CO<sub>2</sub> not just for the end user (hydrogen cars) but back at the primary source.

Low resource demand

- Low land usage
- Minimal water usage
- Minimal emissions
- Minimal green house



- High availability 24-7-365
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    - ity, security, safety, & sustainability) r considerations me to implement nergy return on energy vestment

- 2005: growth in demand will exceed growth in non-OPEC production
- 2008: non-OPEC production will peak in 2 years
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availability 24-7-365 option for developing ries

#### Surety

- y, security, safety, & sustainability)
- Other considerations
  - Time to implement
  - Energy return on energy investment

- Low land usage
- Minimal water usage
- Minimal emissions
  - Ethanol 1.3 gal per gal
  - EGS should be > 10 kW-hr return per kW-hr invested
- Easy reclamation
- Risks & impacts understood
  - Low resource demand
- Energy return on energy investment

Time to implement

nability)

Good option for developing countries

• High availability 24-7-365



# So what is the answer?

Sustainable geothermal production will not meet world energy demand and you can't put geothermal heat in your gas tank.



#### We are already that.





There aren't false expectations that geothermal is the whole solution.

Geothermal has a proven to be environmental and developing country friendly.



#### So what is wrong?

- We don't want to pay replacement costs for energy.
- Too often we make uninformed energy decisions based on emotion: "Will supporting this position make me feel good?"
- The history of geothermal energy shows that emotion does not lead to wise energy choices.
- Ignorance is no excuse in the Torah we are called to repent of sin committed in ignorance.
- We are called to debate for informed, rational energy decisions consistent with Biblical principles.