Potential for Hybrid Solar Thermal Technologies in Gujarat

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Introduction

- Potential of Solar Tech.
- Criticisms and barriers to progress
- Learning from Nature: A hybrid/co-gen solution?
- Our Solution: Key Features
- Conclusions

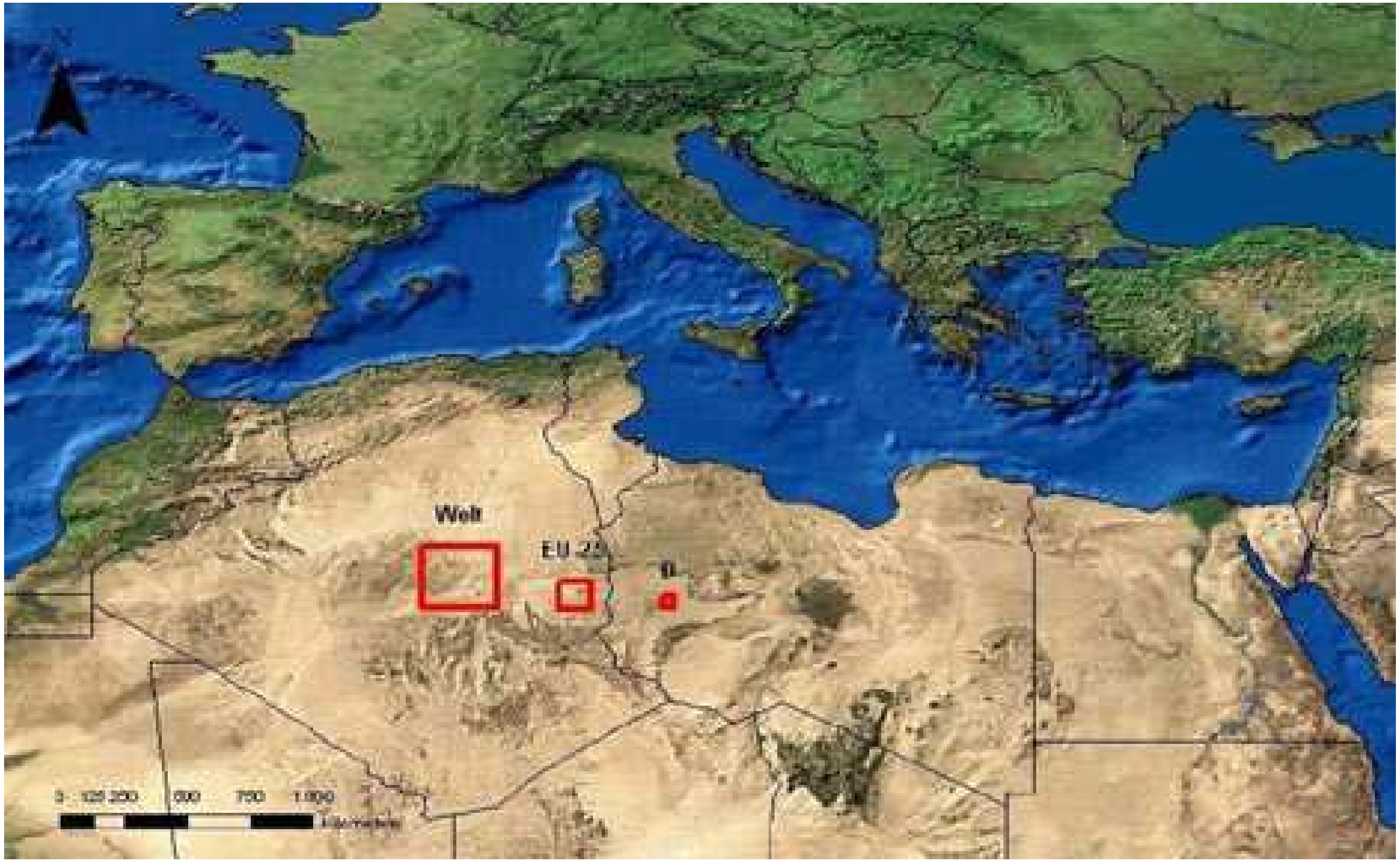
Please interrupt and ask questions!

Solar Power Potentials

- Solar Energy – there's a lot of it!
- Total Global Irradiance 174 PW (10^15 W)
- Global Energy Consumption 16 TW (10^12 W)
- Only need to capture < 0.01% to meet all needs

Solar Power Potentials

- Visually:



A Changing Market Place, A New Opportunity

- Growing public recognition of Global Warming and Energy Security

- Industry perception is changing:
  - Need to be seen to be proactive
  - Promoting energy efficiency
  - Carbon offsetting

- The funds are there
  - Government subsidies
  - Investors stung by volatile markets in abstract derivative products want *real* investments

Criticisms of Solar Tech: Supply vs Demand

- **Spatial asyncronicity**:
  - High elec. Demand often in areas of lowest irradiance
- **Temporal asyncronicity**:
  - Generation only by day
  - Uniform rate of supply, but demand has sharp “peak loads”

$\Rightarrow$ Solar Thermal plants must **rely on back-up** systems (typically fossil fuels)

$\Rightarrow$ Solar Thermal alone **cannot satisfy the market**

Criticisms of Solar Tech: Economic Issues

- Solar **seen as poor competitor**:
  - Coal: 3.88rs/kWh(e)
  - Solar Thermal: 9-12 rs/kWh(e) approx.
  - Typical Buy Price: 5-6 rs/kWh(e)
  - Solar only viable if subsidised
- Solar Thermal production **seen as higher-risk**:
  - Developing technology.
  - Large Scale (eg. Sahara Project)

CST in the Sahara Desert

- Why the Sahara?
- Europe has high demand, but low Irradiance: location not economical
- Near (ish) to Europe
- Near (ish) to equator:
  - low seasonal variation
  - sun higher in sky
- Desert: Low atmospheric moisture

⇒**High annual average irradiance**

CST in the Sahara Desert: Problems!

- Logistic difficulties:
  - **Inhospitable** working environment
  - **Poor transportation** network
  - **No current European-Saharan transmission infrastructure**
- Building infrastructure
  - ⇒ **Long term** project
  - ⇒ Very **Large initial capital** outlay
- Long term + large outlay = **Large Financial Risks**
- Investors want the opposite :
  - High returns
  - Quickly
  - At low Risk

Criticisms of Solar Tech: What to do?

- How can Solar attract investors?
  - Reduction in generation costs per kWe
  - Scalable implementation tailored to risk appetite
  - Reconciling fundamental issues of supply and demand

Hybrid CST: Learning from Nature

- Human systems often perform **singular functions** operating at **low efficiencies** and producing **waste-products**
- Nature doesn't waste anything!
- Ecological systems typically
  - Comprise many **interacting** species
  - Performing **multiple functions**
  - **High overall efficiency** (eg carbon cycling in tropical rainforests)
  - Little or **no waste** (outputs = inputs)

Hybrid CST: Learning from Nature

- **Question:** Can we learn from nature?

- **Aim:** To combine technologies that potentiate each other, producing efficiency savings and reducing waste.

Hybrid CST: Learning from Nature

Some observations about Gujarat:

- High annual Irradiance
- Top producer of **salt**
- Population pressures
  - Increased demand for **electricity**, **food** and **water**
- Scarce water supply:
  - Ground water levels decreasing, as much as 3m/yr
  - Crop production at risk
- Soil erosion & threat of desert expansion

Hybrid CST: Learning from Nature

Idea:

- Desalinate sea/ground water using “waste” heat from CST (co-generation)
- Use desalination “waste” water in local salt production

Hybrid CST: Learning from Nature

Advantages:

- Increased operating efficiency
- Water can be:
  - Sold
  - Irrigation support to local agriculture
- Supports local salt industries:
  - High temp/high conc output => Enhanced productivity
- Water and salt outputs subsidies electricity

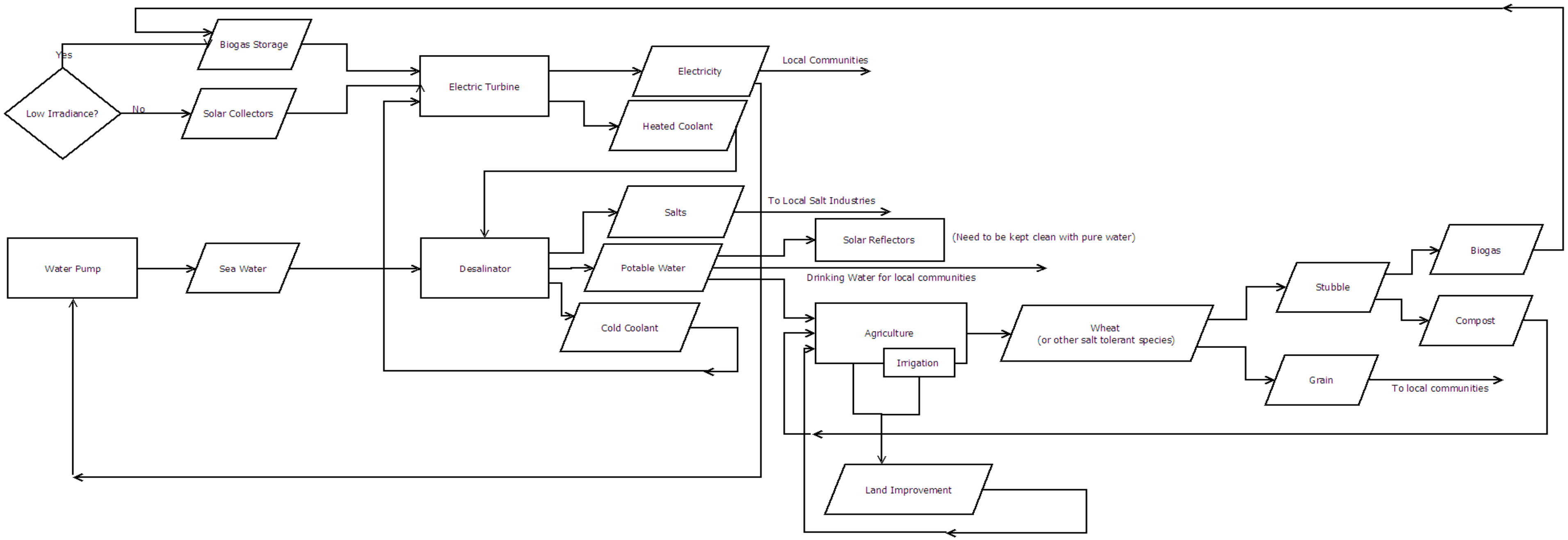
$\Rightarrow$ **competitive electricity prices**

Hybrid CST: Learning from Nature

Further Enhancements:

- Digest/combust waste biomass from local crop production
- Biofuel used at night-time for water/electricity production
- Compost/waste used to improve soil condition

Hybrid CST: Learning from Nature



Hybrid CST: Key Features

Interconnected system:

- “Waste” from one component is an input to another
  - Electricity -> “Waste” Heat -> Desalination
  - Desalination -> “Waste” Conc. Salt Water -> Salt production
  - Desalination -> Crop -> “Waste” biomass -> Biofuel
  - Biofuel -> Electricity

No Waste Products

Hybrid CST: Key Features

<u>Positive Feedback Loops:</u>

- Irrigation water -> Increased yield
- Increased yield -> Increased biofuel
- Increased biofuel -> Increased elec + water
- Increased water -> Increased yield…etc

Hybrid CST: Key Features

<u>Natural “Hedges” (ie. Risk Mitigation)</u>

Example 1:

- A: Hot dry summer -> high irrigation req.
- B: Hot dry summer -> high desalination vol
- Water stress in A compensated by B

Example 2:

- C: Wet summer (low irradiance) -> low elec. Production
- D: Wet summer -> high crop yield -> high biofuel
- More biofuel in D compensates low solar prod. in C

Hybrid CST: Key Features

Multiple Outputs

Electricity
Water
Food
Biofuel
Compost
Salt

- We can **control** production in each **output stream**

⇒ **optimisation** of output, responsive to market conditions

- Efficient allocation of resources
- **More competitive** and robust economic model

Conclusion

- CST is not economically attractive
- Need to Improve efficiency
- Potential savings through hybrid approach
- Multiple outputs address social, industrial and environmental concerns
- Savings could make HCST cost effective

Thank you!