Defense, National Security and Climate Change: Building Resilience and Identifying Opportunities Related to Water, Energy and Extreme Events
June 25-26, 2012 (Washington, DC)

Toward Sustainable Climate Change Policy Solutions: The Need for a Systems Approach

Saeed Hadian
Kaveh Madani
Christopher Rowney
Soroush Mokhtari

Department of Civil, Environmental & Construction Engineering

UCF

1

HEESA
Hydro-Environmental & Energy Systems Analysis
Providing Interdisciplinary and Sustainable Solutions

Overview

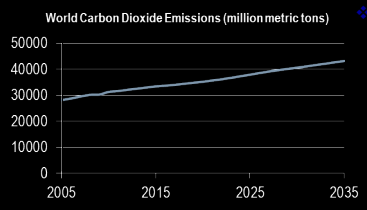
- Conventional Energy Sources and Renewable Energies
- Footprints of Energy
- Efficiency of Different Energy Technologies
- World Energy Generation Capacity
- Conclusions

2

HEESA
Hydro-Environmental & Energy Systems Analysis
Providing Interdisciplinary and Sustainable Solutions

Conventional Energy Sources and Renewable Energies

- Greenhouse gas emissions from burning fossil fuels are increasing dramatically.



  - Greenhouse gas emissions result in:
    - health and environmental problems
    - rising sea levels
    - changing rainfall patterns
    - manipulated ecosystem productivity
    - …

- Fossil fuel resources are becoming more inaccessible.

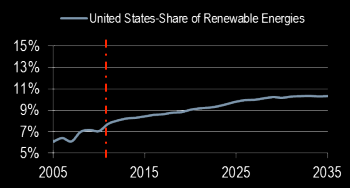
- Fossil fuel resources are not diverse enough.

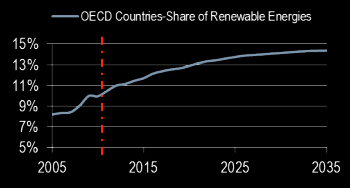
HEESA
Hydro-Environmental & Energy Systems Analysis
Providing Interdisciplinary and Sustainable Solutions

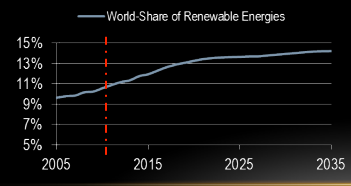
3

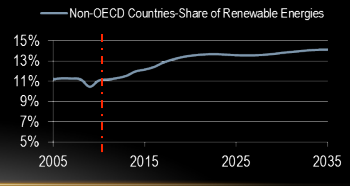
Conventional Energy Sources and Renewable Energies

- Renewable energies are emerging to provide more reliable energy alternatives.









HEESA
Hydro-Environmental & Energy Systems Analysis
Providing Interdisciplinary and Sustainable Solutions

4

Conventional Energy Sources and Renewable Energies

Are renewable energies really green?

Water

Land

By 2035, we need 45% more energy (EIA, 2011)

Cost

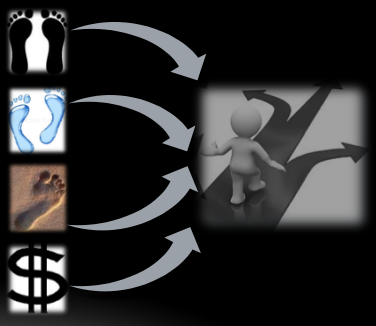
How efficient are different energy technologies with respect to water consumption, land ruse, and cost criteria?

HEESA
Hydro-Environmental & Energy Systems Analysis
Providing Interdisciplinary and Sustainable Solutions

5

Footprints of Energy

- A multi-criteria decision analysis framework (systems approach) is needed to evaluate and develop energy policies.
  - Carbon footprint
  - Water footprint
  - Land footprint
  - Cost of energy production



HEESA
Hydro-Environmental & Energy Systems Analysis
Providing Interdisciplinary and Sustainable Solutions

6

Footprints of Energy

Carbon footprint, water footprint, land footprint, and cost of different energy sources

Energy Sources	Carbon footprint (g CO2/kWh)	Water footprint (m3/GJ)	Land footprint(m2/GWh)	Cost (cent/kWh)
Ethanol from corn	81-85	78	10667-12500	2-4
Ethanol from sugar cane	19	99	9520	2-4
Biomass: wood-chip	25	42	14433-21800	4-10
Biomass: miscanthus	93	37	14433-21800	4-10
Solar thermal	8.5-11.3	0.037-0.780	340-680	4-10
Solar photovoltaic	12.5-104	0.042	704-1760	10.90-23.4
Wind: onshore	6.9-14.5	0.001	2168-2640	4.16-5.72
Geothermal	15.1-55	0.005	33-463	1-8
Wind: offshore	9.1-22	0.001	2168-2640	3.64-8.71
Wave and tidal	14-119	0.001	45-120	5-15
Hydropower	2-48	22	538-3068	3.25-12.35
Coal	834-1026	0.15-0.58	83-567	3.77-5.85
Oil	657-866	4.29-8.60	1490	8-10
Natural gas	398-499	0.1	623	5.46-11.96
Nuclear	9-70	0.42-0.76	63-93	4.55-5.46

* Data collected from 50 peer –reviewed publications.

Efficiency of Different Energy Sources

Rankings based on different MCDM methods

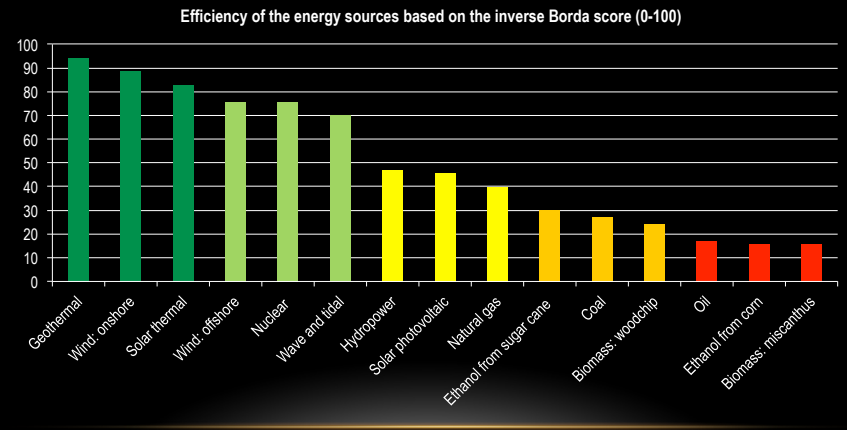
Energy Sources	Dominance	Lexicographic	SAW	TOPSIS	Maximin
Ethanol from corn	12	13	15	15	9
Ethanol from sugar cane	10	7	12	13	12
Biomass: wood-chip	15	10	10	10	13
Biomass: miscanthus	14	15	13	11	11
Solar thermal	3	5	2	2	5
Solar photovoltaic	9	6	7	7	14
Wind: onshore	1	1	4	5	2
Wind: offshore	4	2	6	6	4
Wave and tidal	6	3	5	4	8
Hydropower	8	12	8	8	6
Coal	7	9	11	14	15
Oil	13	14	14	12	10
Natural gas	11	11	9	9	7
Nuclear	5	8	3	3	3
Geothermal	2	4	1	1	1

Final ranking

Energy Sources	Ranking
Geothermal	1
Wind: onshore	2
Solar thermal	3
Wind: offshore	4
Nuclear	4
Wave and tidal	6
Hydropower	7
Solar photovoltaic	8
Natural gas	9
Ethanol from sugar cane	10
Coal	11
Biomass: woodchip	12
Oil	13
Ethanol from corn	14
Biomass: miscanthus	14

HEESA
Hydro-Environmental & Energy Systems Analysis
Providing Interdisciplinary and Sustainable Solutions

Efficiency of Different Energy Sources

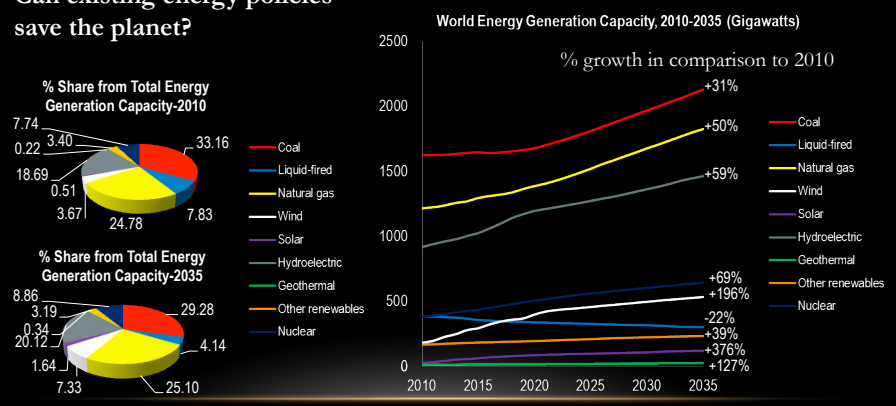


HEESA
Hydro-Environmental & Energy Systems Analysis
Providing Interdisciplinary and Sustainable Solutions

9

World Energy Generation Capacity

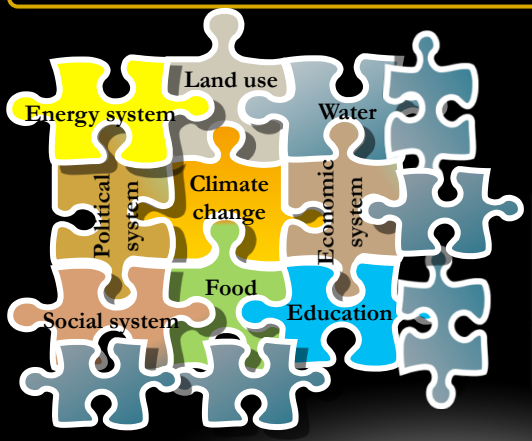
Can existing energy policies save the planet?



HEESA
Hydro-Environmental & Energy Systems Analysis
Providing Interdisciplinary and Sustainable Solutions

10

Conclusions



Moving toward sustainability requires a systems approach

HEESA
Hydro-Environmental & Energy Systems Analysis
Providing Interdisciplinary and Sustainable Solutions

11

Conclusions of the Study

- Efficiency of different energy sources is sensitive to their carbon footprint, water consumption, land footprint, cost, and other factors.
- Not all renewable energies are green.
- Current energy policies do not lead to a sustainable future, due to dramatic unintended consequences.
- A sustainable energy policy will not solve the global warming problem by creating new problems.
- A systems approach (system of systems approach) is needed to develop sustainable energy policies and technologies.
- If we do not have the knowledge, we must slow down!

HEESA
Hydro-Environmental & Energy Systems Analysis
Providing Interdisciplinary and Sustainable Solutions

12

HEESA

Hydro-Environmental & Energy Systems Analysis

Providing Interdisciplinary and Sustainable Solutions

Kaveh Madani
(407) 823-2317
kaveh@ucf.edu