Trade-off between Energy Efficiency improvements and additional Renewable Energy supply: A review of international experiences

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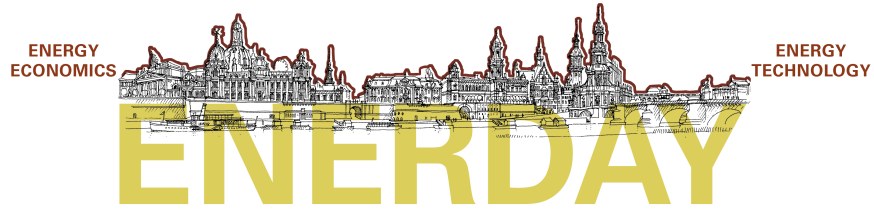


Agenda

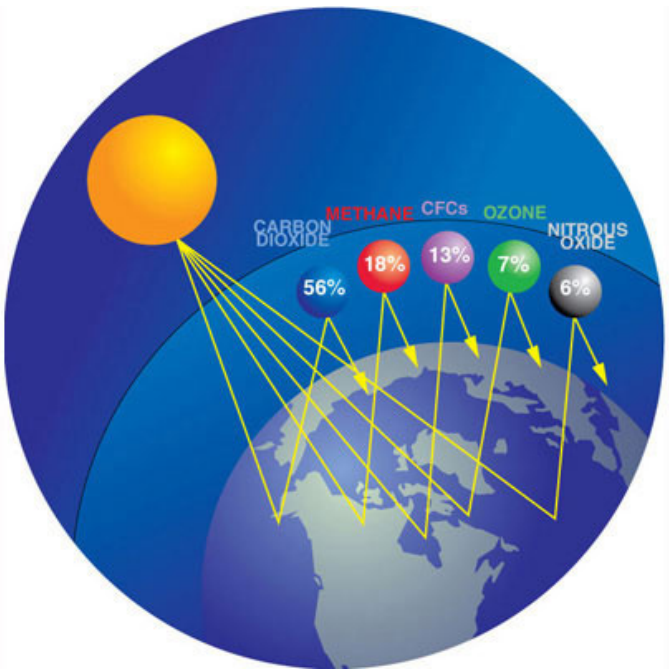
- Introduction to the topic
- Investigation
- Findings
- Conclusions and Future works

Introduction

Problem

The problem:

- Growth in the sectors $\Rightarrow$ Increase of energy demand
- Expansion of energy production power plant's capacity
- Energy production associated with GHGs emissions (NO_x, SO_x, CH_4, CFC, CO_2)
- GHGs are harmful for the environment



Introduction

Solutions

The solutions (IPCC):

- Eliminate fossil fuels combustion processes
- Use GHGs-free energy production processes (**renewables-RES**)
- Better use of the energy produced
- Consume less (improve **energy efficiency-EE**)
- Change the behaviours toward a better use of the energy available (**energy savings**)
- Improve the transport facilities
- ...

Introduction

Small recap

Being EE and RES among the most valid solutions to reduce GHG, how should they be combined to reach an optimal configuration (i.e. trade-off) within the energy system ?

Introduction

Research question(s)

Focus:

- Investigation of studies that deal with trade-off EE-RES (electricity sector)
- Understanding of the process and results

Research question(s):

- How did other studies proceed with the trade-off investigation?
- Which models have been used for the analyses?
- How were the trade-offs assessed?
- Where are the findings pointing to?

Investigation

14 articles (among all) reporting international experience were found to be suitable for the survey

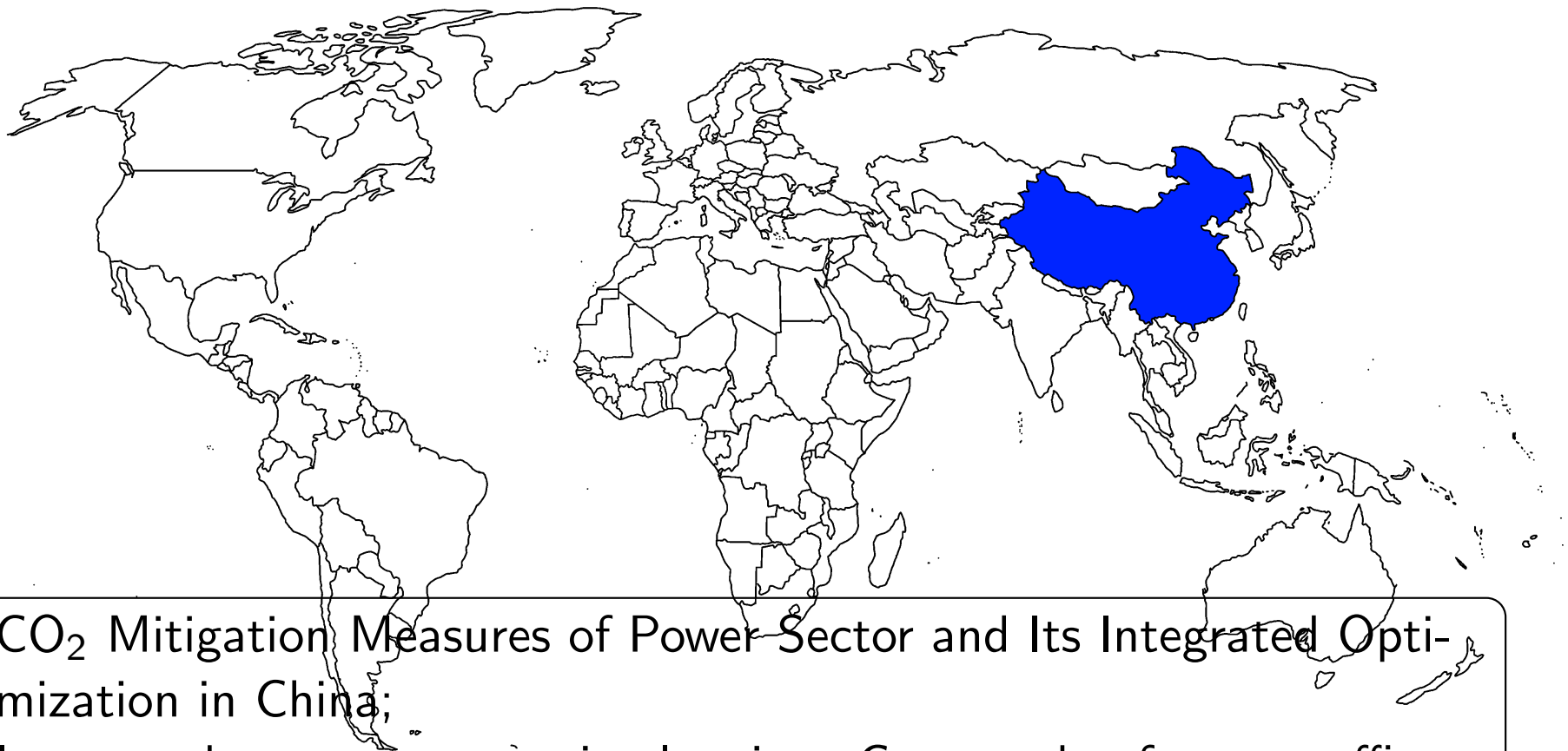
Articles

Assessment of mitigation options for the energy system in Bulgaria (Bulgaria)

Articles

Renewables vs. energy efficiency: The cost of carbon emissions reduction in Spain (Spain)

Articles

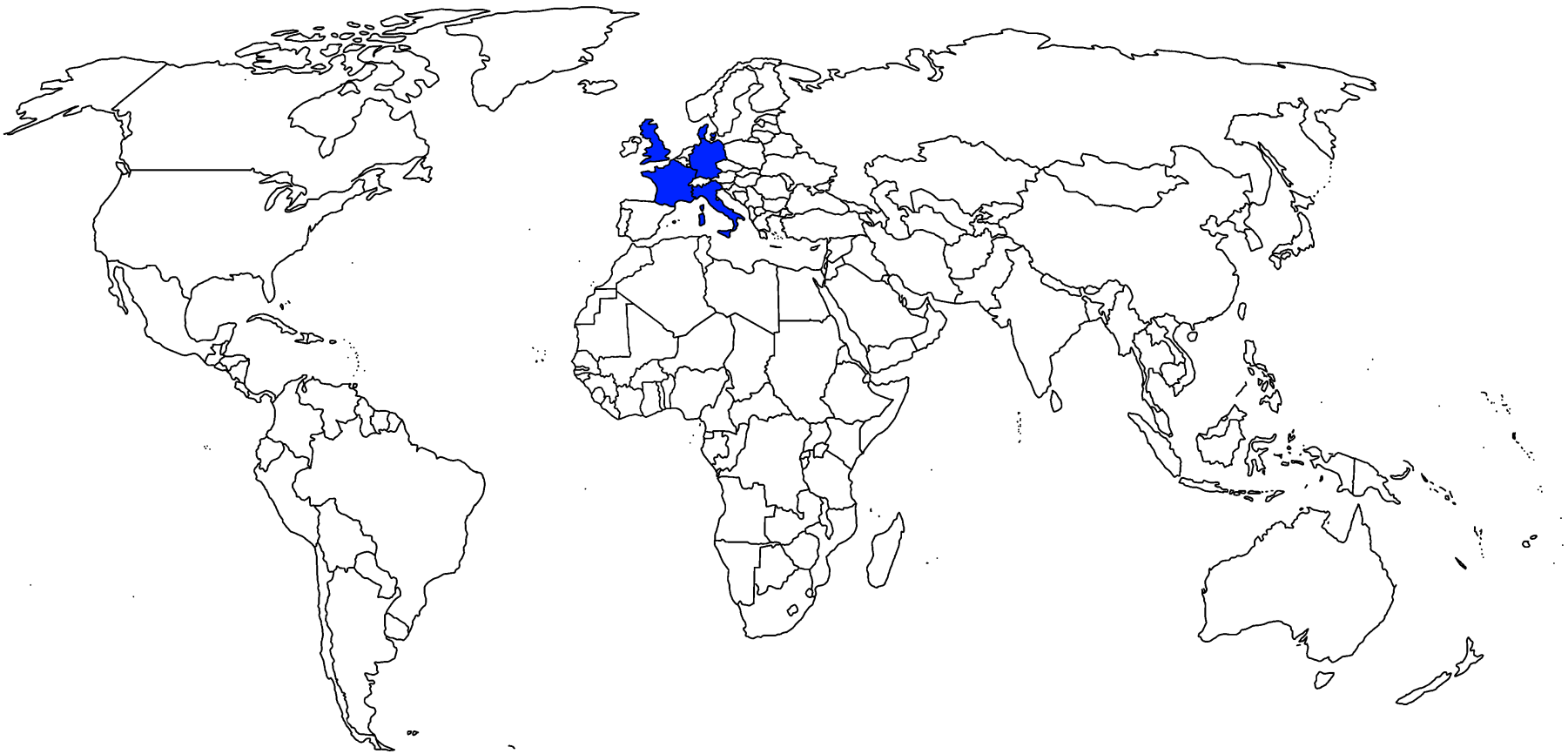


CO_2 Mitigation Measures of Power Sector and Its Integrated Optimization in China;
Integrated resource strategic planning: Case study of energy efficiency in the Chinese power sector;
Nonlinear integrated resource strategic planning model and case study in China's power sector planning (China)

Articles

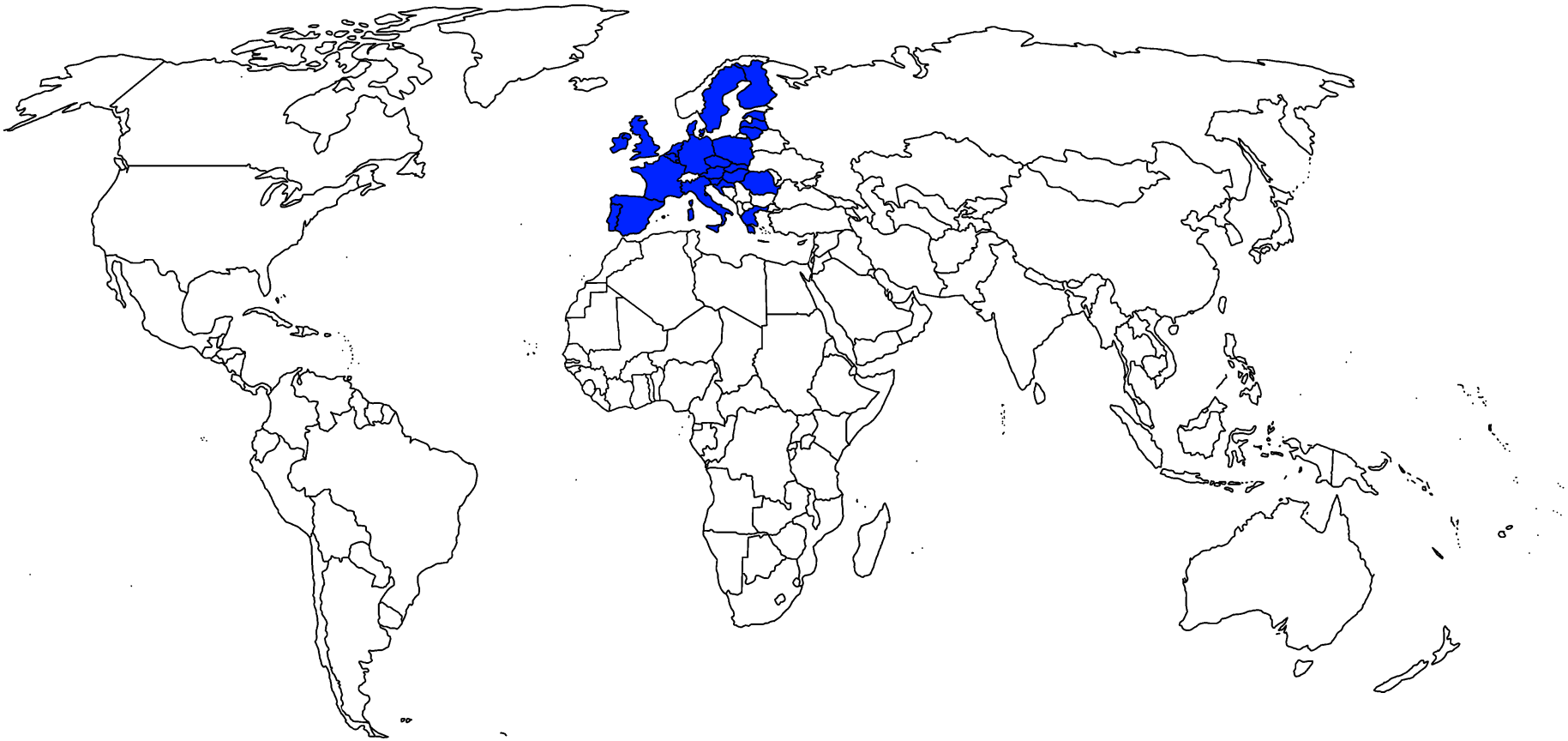
Simulation-based optimization of sustainable national energy systems (Serbia)

Articles



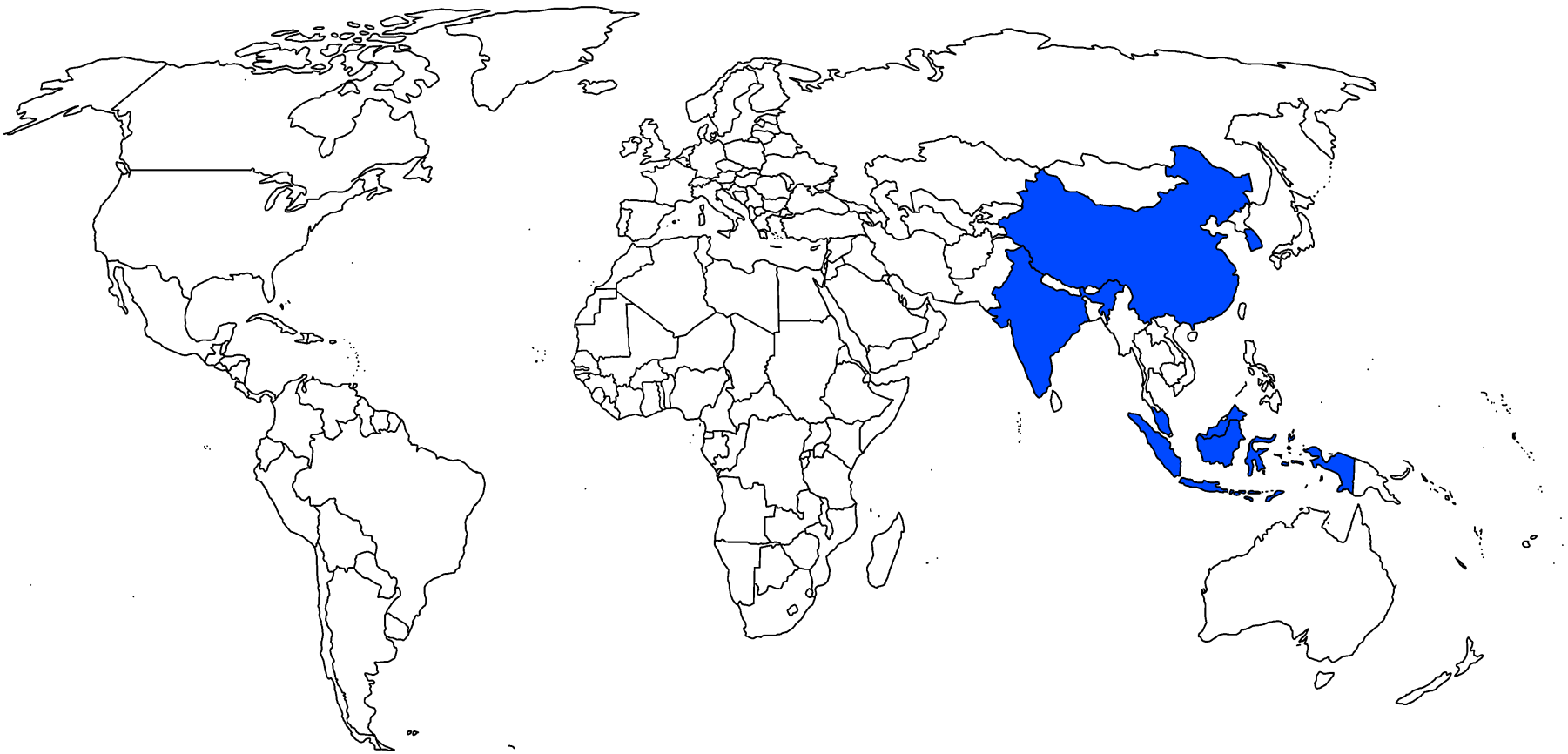
Synergies between renewable energy and energy efficiency. A working paper based on REMAP 2030 (France, Italy, Germany, DK, UK)

Articles



The unrecognized contribution of renewable energy to Europe's energy savings target (Europe)

Articles

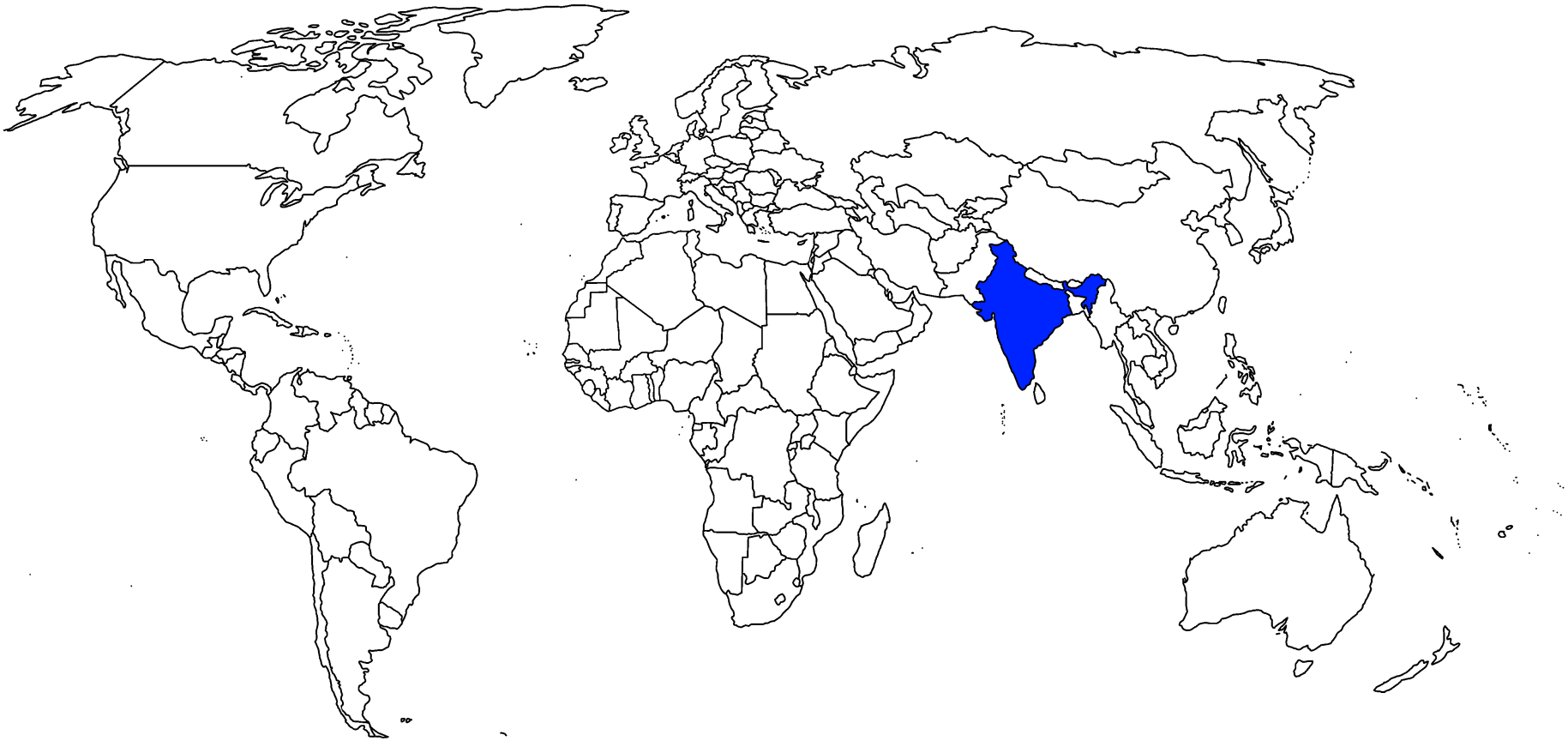


Synergies in the Asian energy system: Climate change, energy security, energy access and air pollution (China, India, Indonesia, Malaysia, South Korea)

Articles

Assessment of the impact of renewable energy and energy efficiency policies on the Macedonian energy sector development (Macedonia)

Articles



Renewable energy for sustainable electrical energy system in India (India)

Articles

Estimating the cost savings and avoided CO2 emissions in Brazil by implementing energy efficient policies (Brazil)

Articles

The impact of demand side management strategies in the penetration of renewable electricity (Portugal)

Articles

Integrated resource planning in the power sector and economy-wide changes in environmental emissions (Indonesia)

Definitions

Mind the difference!

Synergy

Interaction between two factors which combination leads to greater (or smaller) effect than the sum of their separate effects.

Trade off

Refers to a method of reducing/forgoing one/more desirable outcomes in exchange for obtaining other desirable outcomes in order to maximize the total return or effectiveness under given circumstances.

"Synergies and trade-offs between unsustainable trends identified in the European Union- Empirical analysis carried out with the advanced sustainability analysis (ASA) approach",J. Luukkanen, J. Vehmas, F. Allievi, J. Panula-Ontto, J. Kaivo-oja. Research report, 2006

Definitions

Mind the difference!

Energy efficiency

Refers to the technical ratio between the quantity of primary or final energy consumed and the maximum quantity of energy service obtainable (heating, lighting, cooling,...)

Energy savings

Implies the reduction of final energy consumption, through energy efficiency improvements or behavioral change

"Energy saving and energy efficiency concepts for policy making", V.Oikonomou, F. Becchis, L. Steg, D. Russolillo. Energy Policy, 2009

Investigation

Method: Narrow the topic

Key points:

- **Models adopted**
  - Characteristics of the model selected
  - Choice of the model
- **Approach of the analysis**
  - Categorization of the studies (goals, methods, ..)
  - Assessment of the results
  - Differences and similarities

Investigation

Categorization

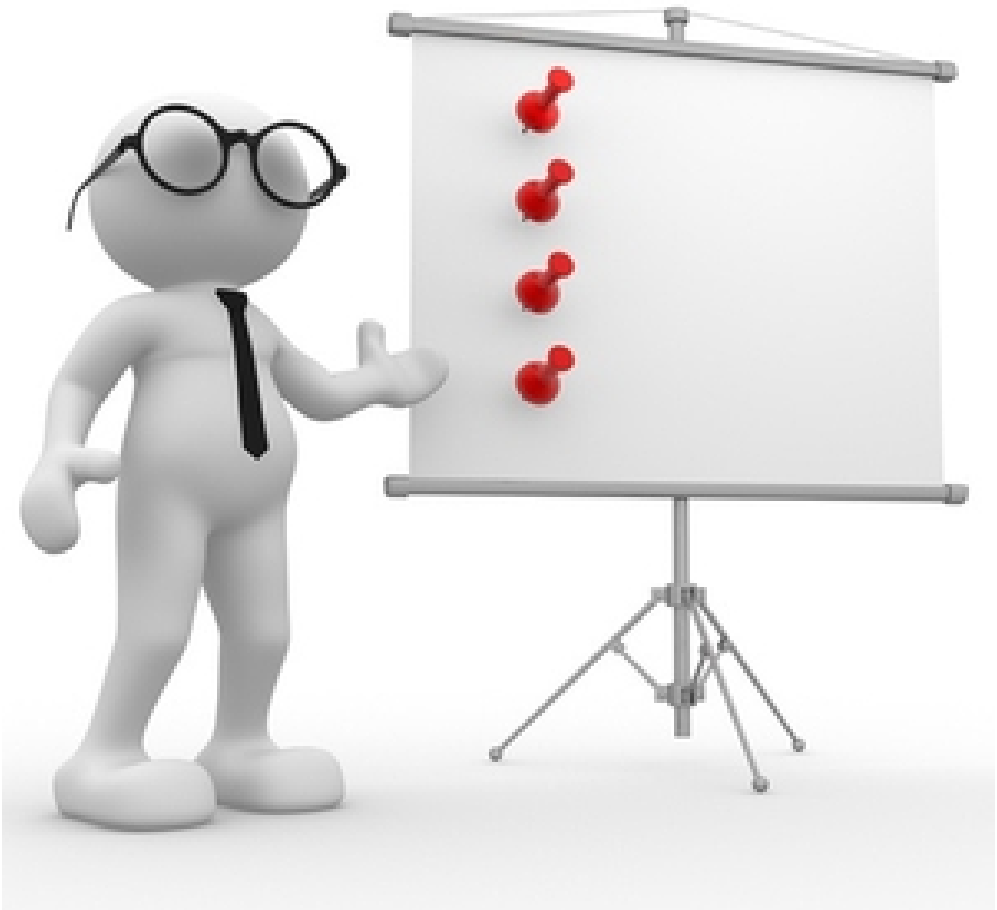
For the models...

Tool	Analytical approach	Mathematical approach	Equilibrium	Model
...	Bottom-up/Top-down/Hybrid	Linear/Non Linear	General/Partial	Static/Dynamic

and for the studies..

Study	Purpose of the study	Methodology	Assessment of the results	Conclusions of the study
...	...	...	...	...

Findings



Findings

Models

1. **Analytical approach**
   - **10 Bottom up**: focus on sectorial and technological details
   - 2 Top down: emphasis on economic wide features
   - 1 Hybrid: combined approach

   $\Downarrow$

   Most of the models focus on the future configuration of energy systems.

2. **Mathematical approach**
   Most of the models are linear. Non linearity was observed in model that presented:
   - Multi-objective optimization approach
   - Non-linear cost supply curves
   - Non linear modules

Findings

Models

3. **Equilibrium**
   A fair split between general (broader) and partial (narrow) equilibrium was found.

4. **Dynamicity**
   The great majority of the models are static (i.e. time independent view of a system) while just 4 were found to be dynamic.

Findings

Studies

1. **Purposes**
   - GHG(CO_2) mitigation option investigation
   - Targets fulfillment study
   - Analysis of policies and programs development
2. **Methodology**
   System optimization/investments-cost minimization while adhering to constraints
3. **Results evaluation**

- Decrease in primary energy
- Increase in RES share
- CO_2 emission levels
- New capacity investments
- Cost of emission reduction
- Energy system costs
- CO_2 emission avoided

Findings

Studies

4 Conclusions of the studies

i. EE measures: most cost-effective options for CO_2 reduction
ii. EE implies popularization costs: hinder further development
iii. Mind the rebound effect: it decreases savings (economic, energy and emissions)
iv. EE measures first, RES after
v. RES-EE: best combination for low system energy costs & high CO_2 reduction (higher system prices)
vi. Synergies between RES-EE commonly acknowledged, trade-offs still not well defined.
vii. EE can act positively (short-term) and negatively (long-term) on RES deployment

Conclusions

Summing up

Conclusions

Summary

Key points:

- RES-EE trade off is fundamental for energy system planning
- Trade off leads to economic & environmental benefits
- Inaccurate considerations can hinder RES development
- Contextualization matters when selecting approach & tools

Utility of the results (for whom & how):

- **Myself** (familiarize with the topic)
- Make **readers** acquainted with the topic
- Guidance for **decision-makers** looking for a suitable analysis regarding trade-offs (different objectives)

Conclusion

Future works

Investigation on the trade-off between RES-EE in Denmark:

- What should be the share of RES and EE in the system, given a pre-defined goal?
- Which technologies/measures are more suitable to cover the share for each system?

Thank you for your attention

Questions, critiques and suggestions