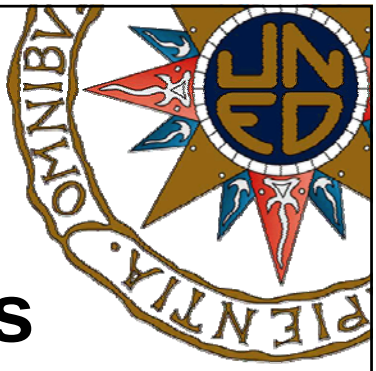

Energy security indices in Europe

Economic Challenges for Energy Workshop

February 7-8th 2011, Madrid

FUNDACIÓN RAMÓN ARECES

economics for energy

Beatriz Muñoz Delgado
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REACCESS

Contents

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1. Energy security: Conceptual review

Security of energy supply (importer) ➡ Quantities & Prices

"[Energy security is] the continuous availability of energy in varied forms, in sufficient quantities and at affordable prices" (UNDP, 2001).

"Energy security, defined in general terms, means adequate and reliable supplies of energy at affordable prices" (IEA, 2007).

Security of energy demand (exporter) ➡ Income

Risk to the energy supply exists if there is the possibility of a partial or total interruption of physical energy flow (*physical risk*) or a major shift in energy prices (*economic risk*).

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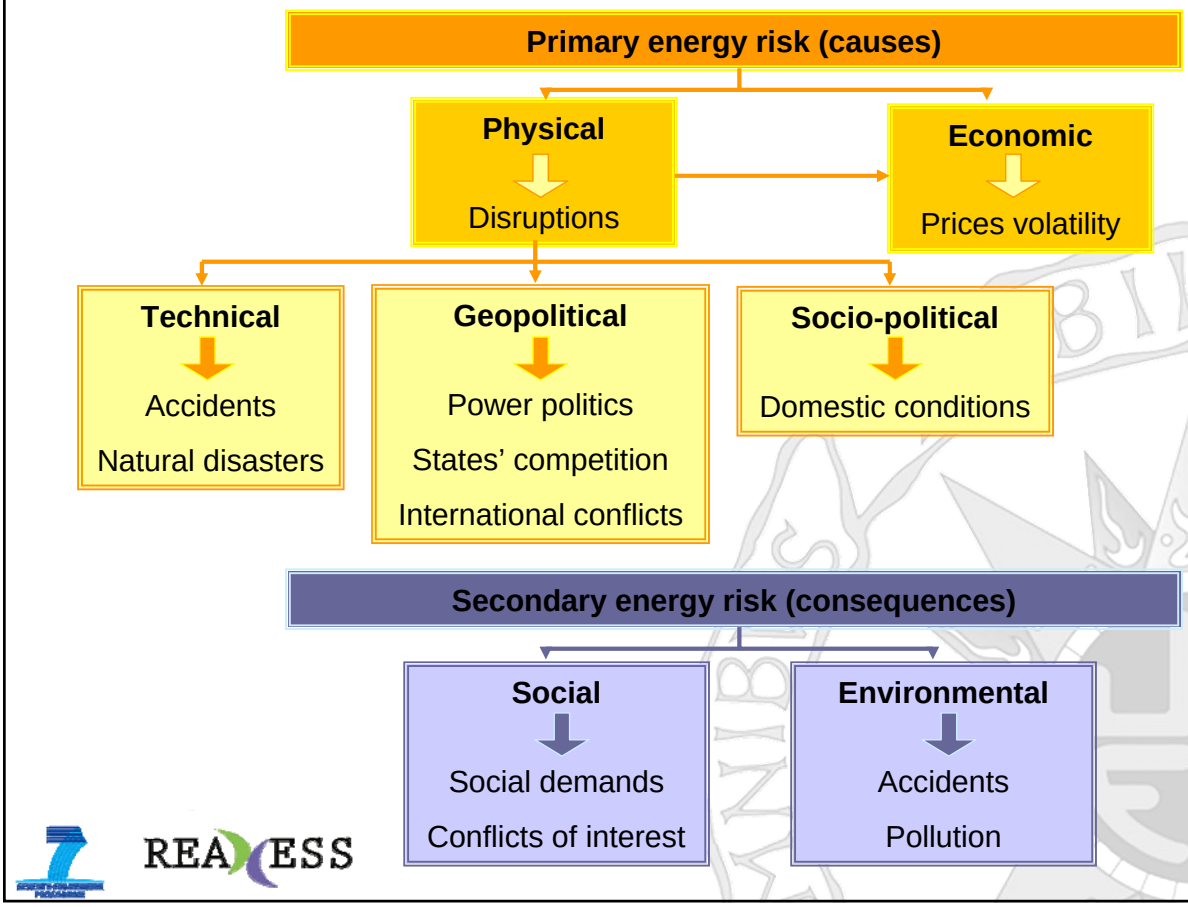
1.1. Energy security: Types of energy risks



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2.1. Energy security quantification: Simple or disaggregated indicators

1. Dependence

1.1. Import dependence indicators

1.2. Total self-sufficiency

2. Vulnerability

2.1. Concentration/diversity

- *Herfindahl-Hirschman Index*
- *Shannon Index*
- Market/Mix shares

2.2. Energy intensity

2.3. Energy efficiency

2.4. Energy consumption p.c.

2.5. Minimum security reserves

2.6. Storage capacity

2.7. Geoeconomic Vulnerability Index

3. Connectivity

3.1. Volumes of gas/electricity imported with regard to total production/imports

3.2. Capacities (gas/electricity)

4. Resources availability

4.1. Resource estimates

4.2. Reserves to production ratios

5. Sustainability

5.1. Share of zero-carbon fuels

6. Market related

6.1. *Energy Affinity Index*

6.2. Market liquidity

6.3. Energy prices

6.4. Market power

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2.2. Energy security quantification: Composite or aggregated indicators

1. *Shannon Index* based (Jansen et al., 2004)
2. *Geopolitical Energy Security Measure* (Blyth & Lefevre, 2004)
3. *Energy Security Indexes: ESI$_{price}$ + ESI$_{volume}$* (IEA, 2007)
4. *Supply/Demand Index* for long-term security of supply (Scheepers et al., 2007)
5. *Willingness to Pay Function for Security of Supply* (Bollen,2008)
6. *Oil Vulnerability Index* (Gupta, 2008)
7. *Risky External Energy Supply* (Le Coq & Paltseva, 2009)
8. *Socioeconomic Energy Risk Index* (Marín, et al.,2009)

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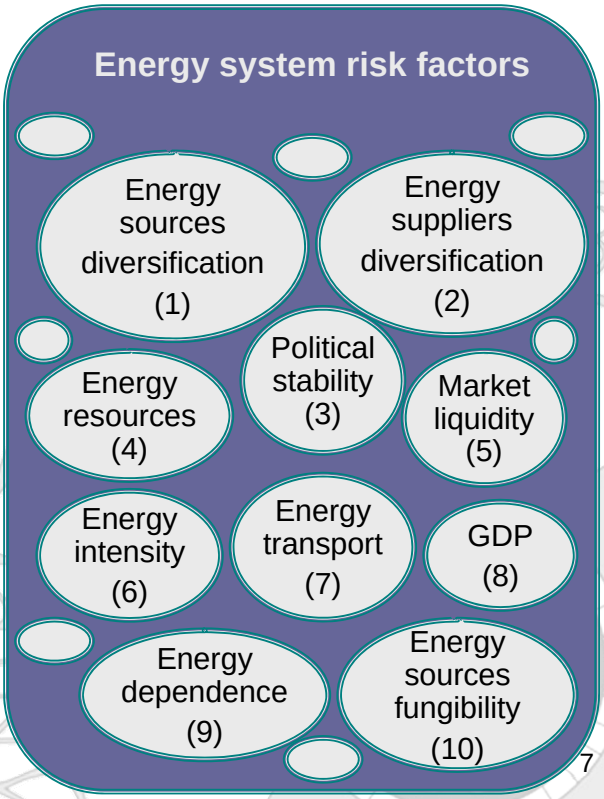
2.2.1. Energy security quantification: Composite or aggregated indicators' factors

1. *Shannon Index* based: (1)+(2)+(3)+(4)
2. *Geopolitical Energy Security Measure:* (2)+(3)+(5)
3. *ESIprice*: (1)+(2)+(3) & *ESIvolume*: (7)
4. *Supply/Demand Index*: all
5. *Willingness to Pay Function for SoS*: (1)+(6)+(9)
6. *Oil Vulnerability Index*: (1)+(2)+(3)+(4)+(5)+(6)+(8)+(9)
7. *Risky External Energy Supply*: (1)+(3)+(7)+(9)+(10)
8. *Socioeconomic Energy Risk Index*: all



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3. REACCESS project & UNED's role

1. *Risk of Energy Availability: Common Corridors for Europe Supply Security* (http://reaccess.epu.ntua.gr/Home.aspx)
2. Funded by 7th Framework Programme of the EC (4.09 million €)
3. Partners: 11 EU + 3 extra-EU (Norway, Russia & Kazak.)
4. Objective: to analyze the European energy corridors with a partial equilibrium techno-economic model (TIMES) which minimizes the total cost of the energy system taking into account technical, environmental and socio-economic risks.
5. Goal: To search for the most efficient cost/risk combination.
6. UNED Research group on "International political economy - Energy" (http://www.goo.gl/FqG5) Leader of the WP4.
    - To analyze the socio-economic risks and reliability of European energy supply to provide inputs for the stochastic modelling.

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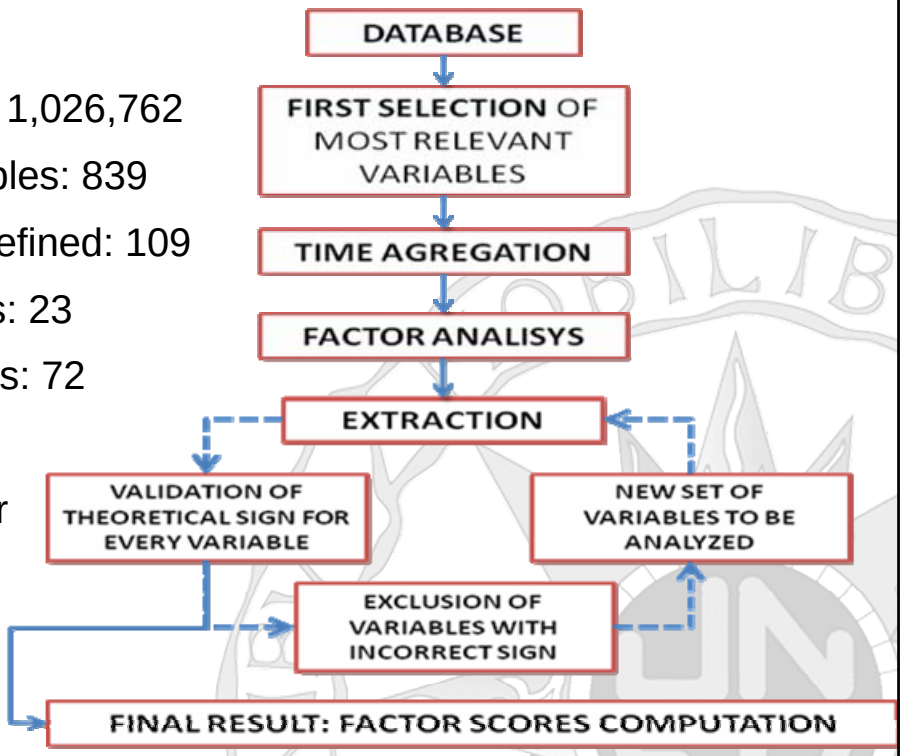
4. Energy risk assessment process

1. Nr. Countries: 199
2. Nr. Collected data: 1,026,762
3. Nr. identified variables: 839
   - Key variables defined: 109
4. 1st level categories: 23
5. 2nd level categories: 72
6. Main risk factors: 4
   - Economic factor
   - Energy factor
   - Political factor
   - Social factor



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4.1. Risk assessment: Dimensions of energy security risk

1. **Economic-driven risk**: a country's energy risk derived from its economic characteristics, including its energy trade patterns (ie. energy intensity, income from energy,…)
2. **Intrinsic energy risk**: energy risk emerging from a given energy resource base and energy imports concentration (ie. reserves-to-production ratios, HHI,…)
3. **Political-institutional risk**: energy risk derived from institutional and political factors that may imply both internal and/or external political frictions (ie. institutional quality, political stability, prevalence of the rule of law…)
4. **Social risk**: risk emerging from social factors that usually imply internal turmoil (ie. social equity, social & labour conflict…)

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4.1.1. Risk assessment: Economic factor

Economic factors	
A.1 Energy internal consumption of exporting countries	**A.4 Size of energy revenues**
A.1.1 Economic growth	A.4.1 % of GDP
A.1.2 Population growth	A.4.2 % of goverment budget
A.1.3 Industrial Gross Value Added	A.4.3 % of exports
A.1.4 Energy intensity	A.4.4 % of trade balance
A.1.5 Energy intensity per capita	**A.5 Trade relation with EU**
A.1.6 Fiscality to internal energy consumption	A.5.1 Trade agreements
A.2 Energy internal consumption of importing countries	A.5.2 EU share of trade balance
A.2.1 Economic growth	A.5.3 Trade volume with EU
A.2.2 Population growth	A.5.4 Trade intensity with EU
A.2.3 Energy intensity	**A.6 Investment**
A.2.4 Energy intensity per capita	A.6.1 Foreign Direct Investment of the EU abroad
A.2.5 Energy dependence and vulnerability	A.6.2 Foreign Direct Investment in the EU
A.2.6 Relative energy taxation	A.6.3 Sovereign wealth funds
A.2.7 Real relative energy prices	
A.3 Competition between major importers	
A.3.1 Political affinity	
A.3.2 Relative trade balance	
A.3.3 Foreign Direct Investment	
A.3.4 Relative index of geographical energy imports dependence	

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4.1.2. Risk assessment: Intrinsic energy factor

Energy factors	
B.1	**Dependence & vulnerability**
B.1.1	**Energy dependence**
B.1.2	**Energy vulnerability**
B.2	**Energy reserves**
B.2.1	**Proved reserves**
B.2.2	**Undiscovered reserves**
B.2.3	**Known oil**
B.2.4	**Reserves/production ratio**
B.2.5	**Reserves reliability**
B.3	**Emergency stocks in importing countries**
B.2.1	**Days forward demand covered by OECD stocks**
B.2.2	**Total stocks on lands in OECD countries**

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4.1.3. Risk assessment: Political-institutional factor

Political factors	
C.1 EU external relations	C.6 Democracy index
C.1.1 Political affinity	C.6.1 Political regime
C.1.2 EU delegations	C.6.2 Democracy indicators
C.1.3 Official Development Aid	C.7 Institutional quality
C.1.4 Inmigration to the EU	C.7.1 Gobernance
C.1.5 Agreements with the EU	C7.2 Membership in International
C.2 Country risk assessment	C.8 Political violence
C.2.1 Country risk rating	C.8.1 Risk of international conflicts
C.2.2 Public debt rating	C.8.2 Risk of internal conflicts
C.2.3 General economic risk	C.8.3 Risk of coup d'etat
C.3 OPEC membership	C.8.4 Terrorism
C.3.1 OPEC countries	C.9 Rule of law
C.4 Ownership of Energy Companies	C.9.1 Corruption
C.4.1 Countries with NOC´s	C.9.2 Ease of doing business
C.4.2 Countries with IOC´s operations	
C.5 Energy reputation	
C.5.1 Use of energy as a weapon	
C.5.2 Participation in multilateral energy agreements	

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4.1.4. Risk assessment: Social factor

Social factors	
D.1	Cultural proximity
D.1.1	Common language
D.1.2	Common values
D.2	Social equity
D.2.1	Social inequity
D.2.2	Migrations
D.2.3	Unemployment
D.2.4	Human Development
D.2.5	Poverty
D.2.6	Per Capita Income
D.2.7	Per Capita Income (Power purchasing parity)
D.3	Social conflicts
D.3.1	Crime
D.3.2	Ethnic fractionalization
D.3.3	Religious fractionalization
D.4	Laboral conflicts
D.4.1	Strikes
D.4.2	Absenteeism

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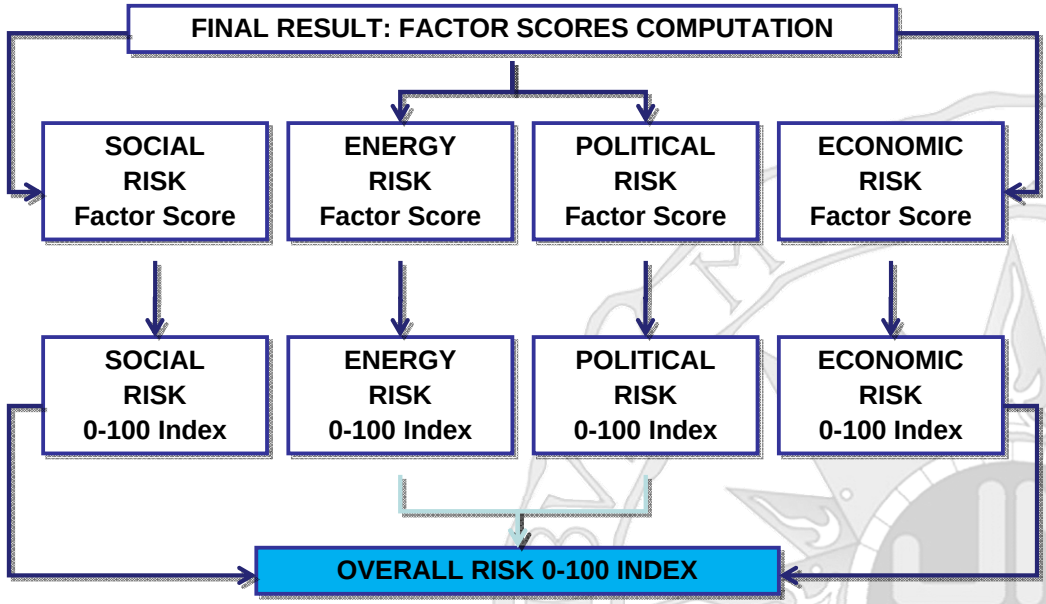
4.2. Risk assessment: Computation of the overall risk



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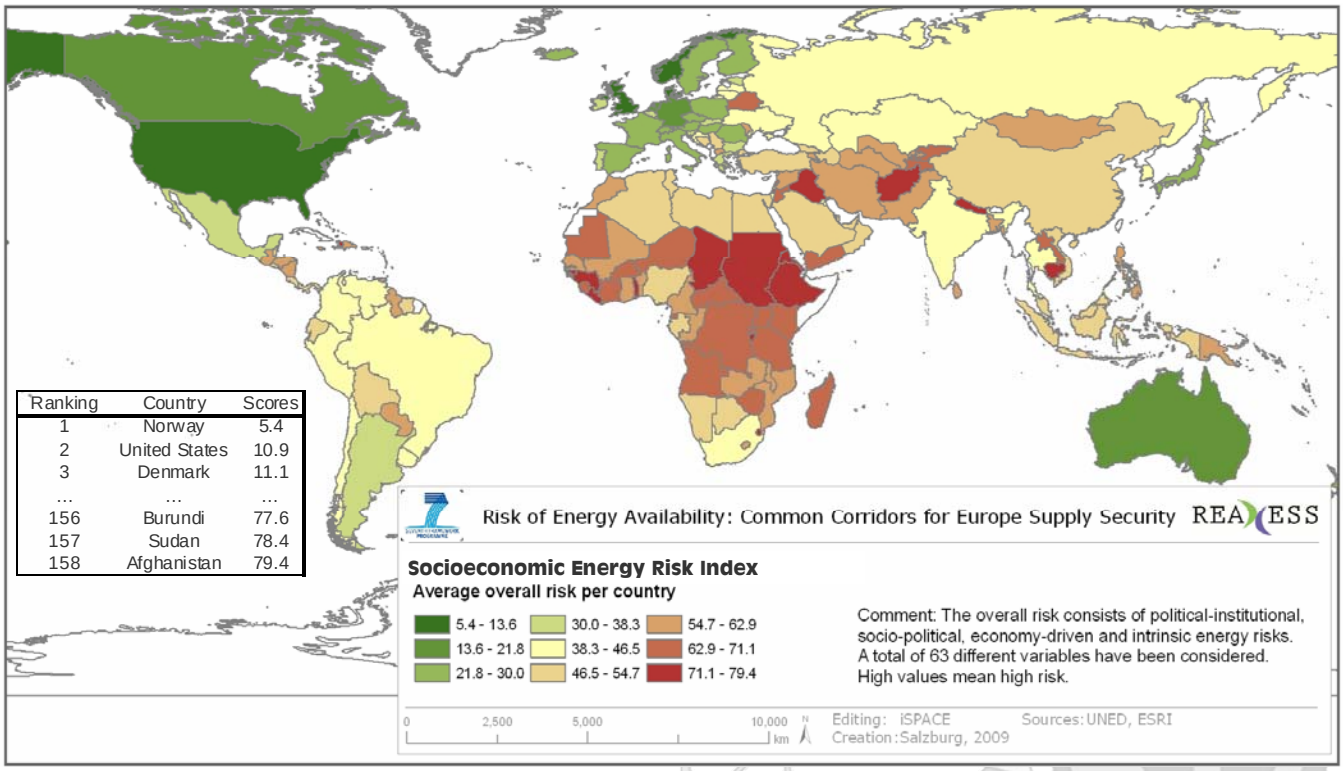
5. *Socioeconomic Energy Risk Index* scores



Ranking	Country	Scores
1	Norway	5.4
2	United States	10.9
3	Denmark	11.1
...	...	...
156	Burundi	77.6
157	Sudan	78.4
158	Afghanistan	79.4

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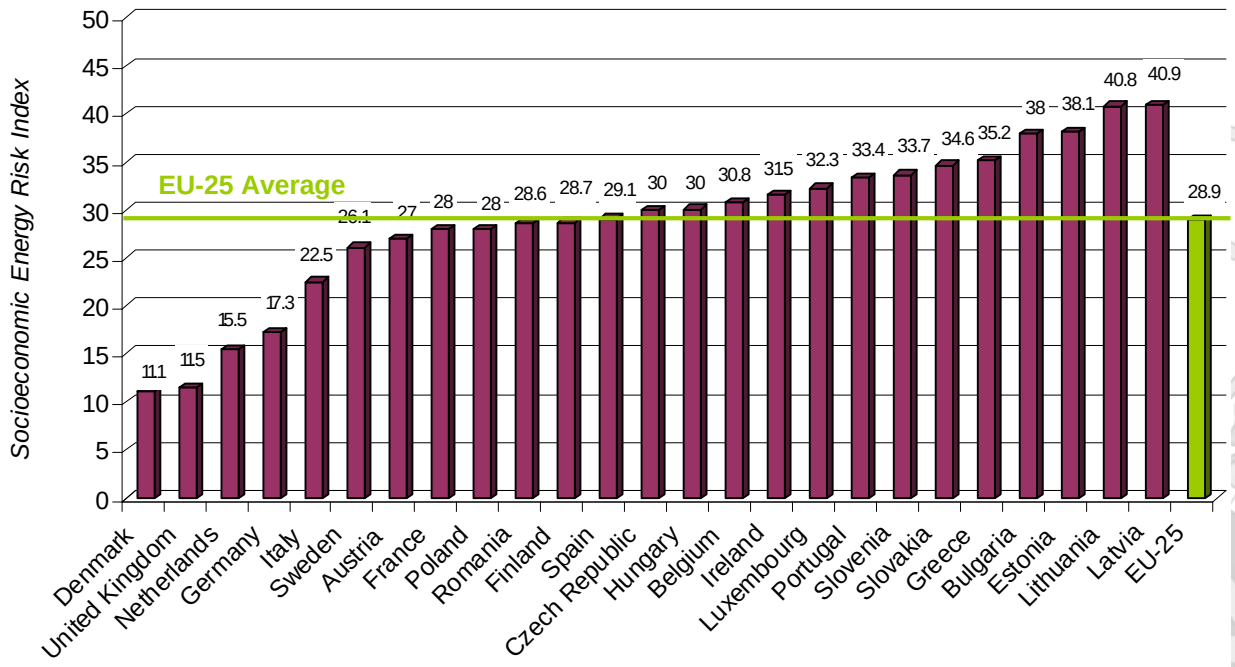
5.1. *Socioeconomic Energy Risk Index* scores in the EU-25



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5.2. *Socioeconomic Energy Risk Index* in the EU-25: rankings by factors

Economic risk		Energy risk		Political risk		Social risk	
United Kingdom	8.1	United Kingdom	17.7	Denmark	0.0	Luxembourg	4.1
Netherlands	12.1	Romania	18.1	Finland	0.8	Netherlands	4.8
Germany	13.5	Denmark	22.1	Sweden	1.1	Sweden	6.6
Hungary	13.6	Italy	33.7	Luxembourg	3.4	Germany	7.4
Italy	14.1	Germany	38.2	Ireland	5.5	Belgium	7.6
Denmark	14.6	Poland	38.8	Netherlands	6.0	Denmark	7.6
Finland	16.1	Netherlands	39.1	Austria	6.8	Finland	7.8
Belgium	16.2	Czech Republic	58.7	United Kingdom	9.7	Ireland	9.2
Slovakia	16.7	Bulgaria	60.5	Germany	9.9	United Kingdom	10.3
Poland	16.7	Spain	60.9	Belgium	10.5	France	10.9
Portugal	16.8	Hungary	61.1	Slovenia	15.8	Austria	11.5
France	17.3	Greece	64.7	France	16.9	Spain	13.1
Czech Republic	17.8	France	66.8	Portugal	17.5	Portugal	15.1
Austria	18.1	Austria	71.7	Spain	19.0	Italy	18.5
Sweden	18.4	Slovakia	77.1	Estonia	21.2	Slovenia	18.7
Latvia	19.7	Sweden	78.3	Czech Republic	22.4	Hungary	20.9
Slovenia	19.7	Slovenia	80.5	Slovakia	22.6	Czech Republic	21.0
Greece	21.0	Ireland	82.8	Italy	23.8	Slovakia	22.2
Lithuania	21.1	Estonia	83.8	Lithuania	23.8	Estonia	25.0
Estonia	22.6	Portugal	84.2	Hungary	24.7	Lithuania	26.6
Romania	22.7	Latvia	88.2	Latvia	25.3	Greece	27.2
Bulgaria	22.9	Belgium	89.0	Greece	27.7	Poland	27.5
Luxembourg	23.3	Finland	89.9	Poland	29.1	Latvia	30.6
Spain	23.4	Lithuania	91.8	Bulgaria	35.4	Bulgaria	33.2
Ireland	28.7	Luxembourg	98.3	Romania	37.7	Romania	36.1
EU-25	**18.2**	**EU-25**	**63.8**	**EU-25**	**16.7**	**EU-25**	**16.9**

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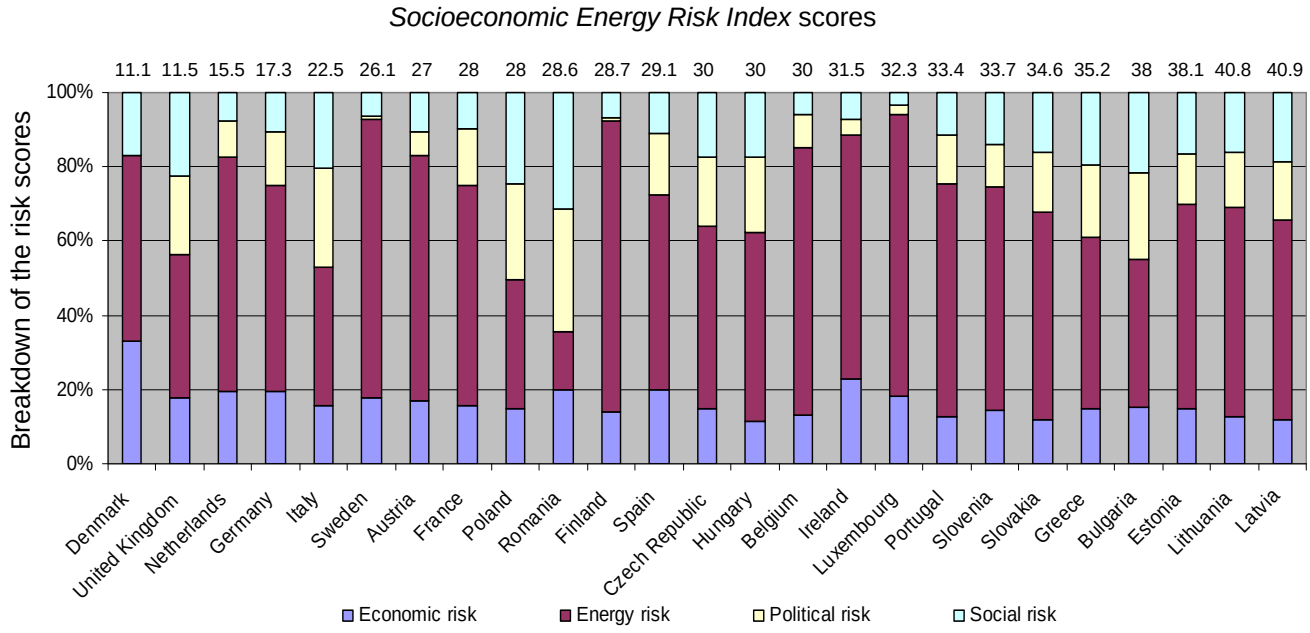
5.3. *Socioeconomic Energy Risk Index* in the EU-25: risk scores breakdown



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6. REACCESS' energy risk assessment

1. The *Socioeconomic Energy Risk* has been addressed on a country basis, but risks is also allocated:
   - At corridor level
   - By type of fuel
2. Each corridor is divided in the same number of segments than the number of countries crossed & the chokepoints in transit.
3. A risk value is assigned to each segment of the corridor.
4. The index allows the construction of a risk index for the whole corridor.
5. Chokepoints risk assessment:
   - Chokepoints inside a country >> bear the risk of the country
   - Chokepoints between various countries >> assign a risk index equal to the average of the indexes of the countries which border them

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7. Alternatives for socioeconomic risk aggregation

a) The highest $r_{se}(n)$ value of the corridor countries and chokepoints is used as R(c)

$$R(c)^a = Max\ r_{se(n)}$$

b) The average of the $r_{se}(n)$ values of the corridor countries and chokepoints is used as R(c)

$$R(c)^b = \frac{\sum_n r_{se(n)}}{n}$$

c) A modified value of the $r_{se}(n)$ average is used as R(c), bearing the highest value in mind

$$R(c)^c = \frac{R(c)^a + R(c)^b}{2}$$

d) The sum of the $r_{se}(n)$ values of the countries and chokepoints forming the corridor is used as R(c)

$$R(c)^d = \sum_n r_{se(n)}$$

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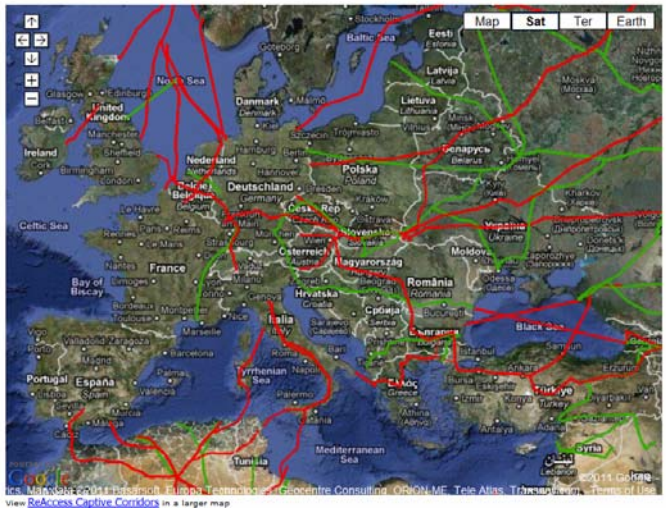
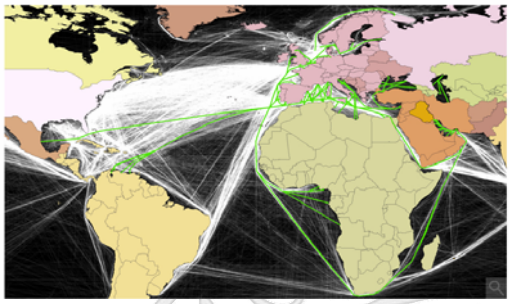
8. Energy corridors description

Reaccess Captive Corridors

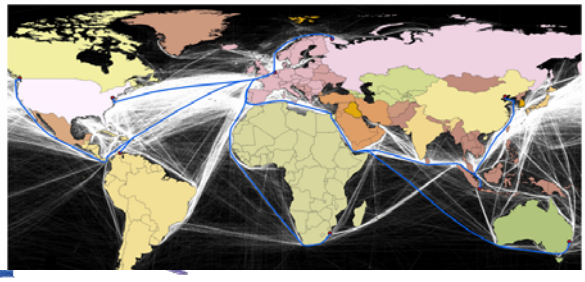


View ReAccess Captive Corridors in a larger map

Oil Routes



Coal Ship Routes and Ports



Reaccess Powerlines

View ReAccess Powerlines in a larger map

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9. Final remarks

1. Further development in the energy security field is needed.
2. There are some difficulties in measuring the socioeconomic energy risk.
3. The quantification of the socioeconomic energy risk is not a probability.
4. There is no obvious best way to aggregate the risks by corridor.
5. Technical risks have been estimated and aggregated separately.
6. Modelling scenarios with a horizon 2050 have been considered.
7. Currently: Waiting for the models outputs. Final meeting: March 2011.
8. The results will be presented as the search for the most efficient cost/risk combination and published by the EC.
9. Conclusions for the EU-25:
   - One of the most secure regions in the world for the energy supply.
   - The riskiest countries in the EU-25 are the eastern ones.
   - The most secure EU members are in the north and the centre.
   - Energy-intrinsic factor involves the highest risk values and disparity.

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Thank you for your attention

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