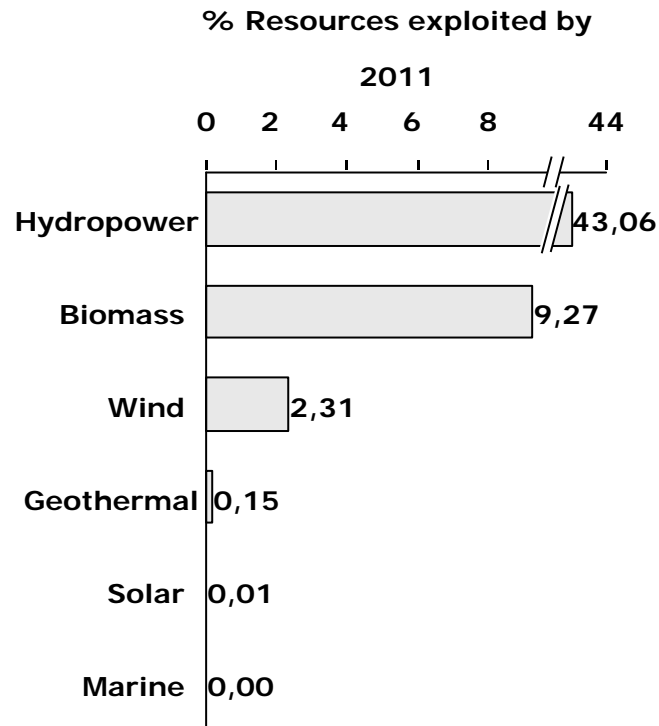

What is the potential for renewable energy?

Introduction to the sector

31/10/2012

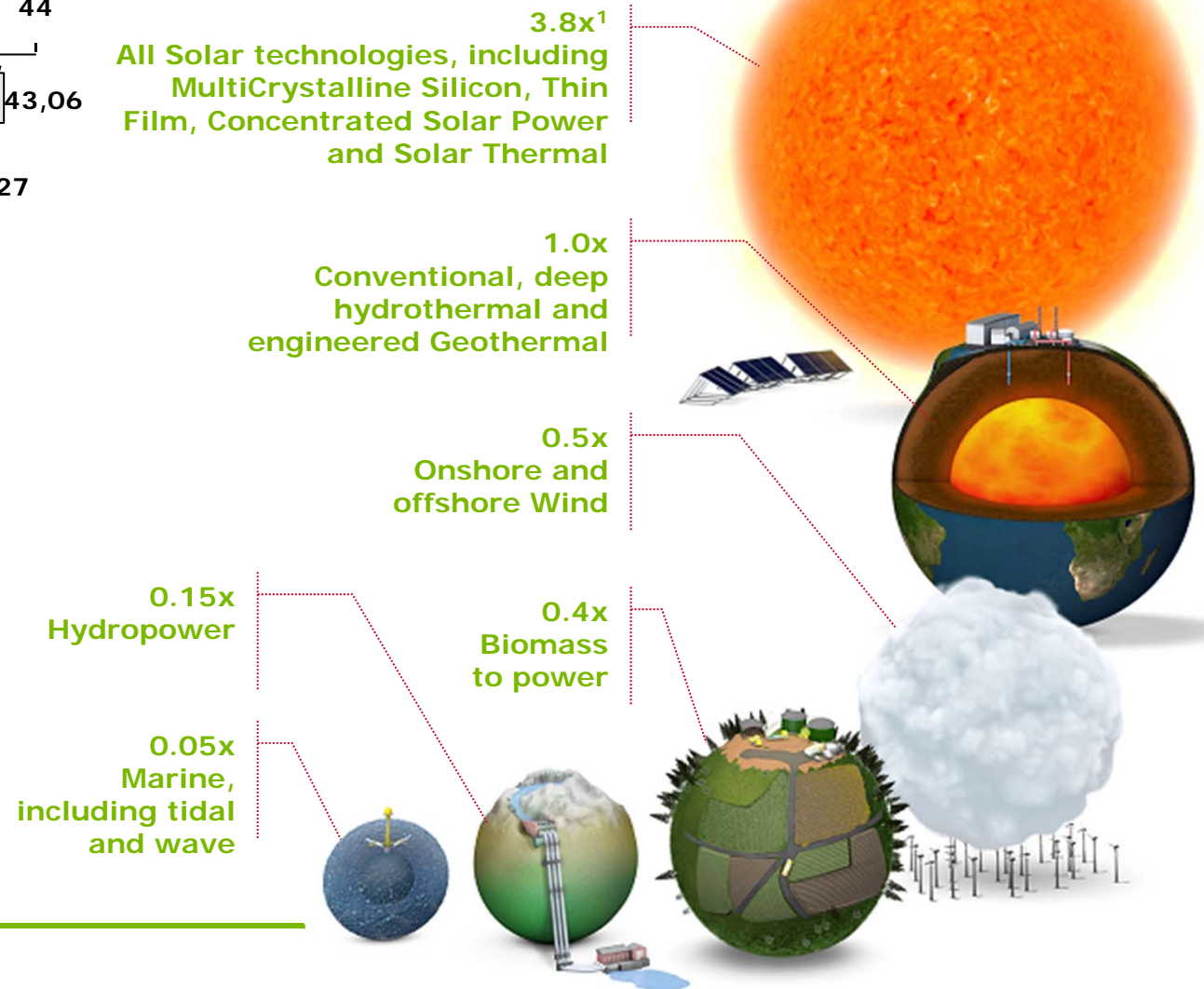
A Gardiner and I de Lovinfosse, Ecofys

Estimates of global renewable resources are very material on a global scale



¹ Read: Solar resources could provide close to 4 times as much energy as the world needs today

Source: BP Statistical Review, EU Renewable Association, BP AE Strategy & Fundamentals



Value of renewable energy



2020
40% renewable generation – avoided
imports 13 – 21 bn €/year

Source: Leitstudie 2010, BMU

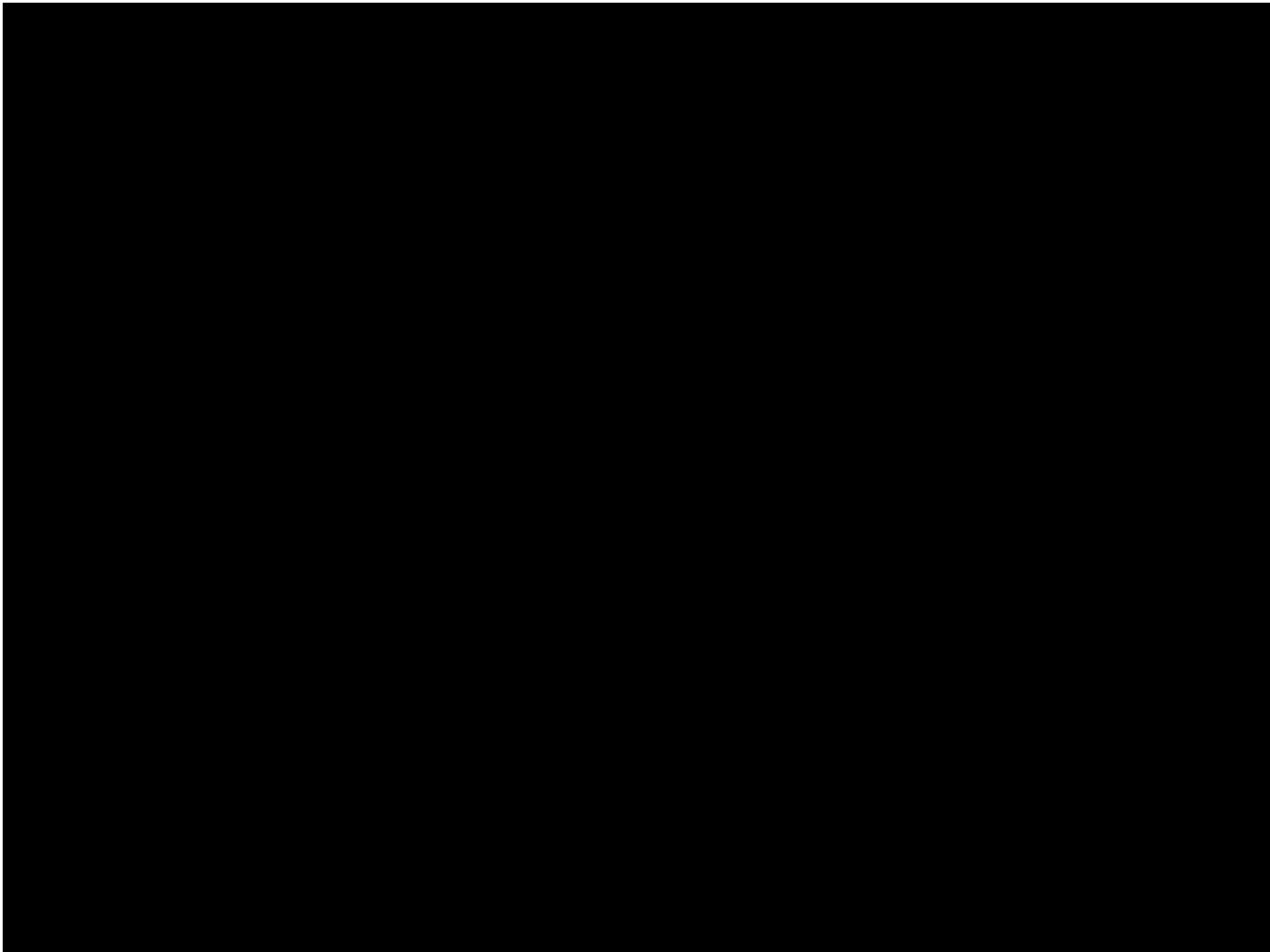


Global annual value of renewable capacity

2010 \$195 bn

2030 \$460 bn

Source: Bloomberg New Energy Finance, Global
Renewable Energy Outlook 2011, annual build capacity
multiplied by country-specific capital costs

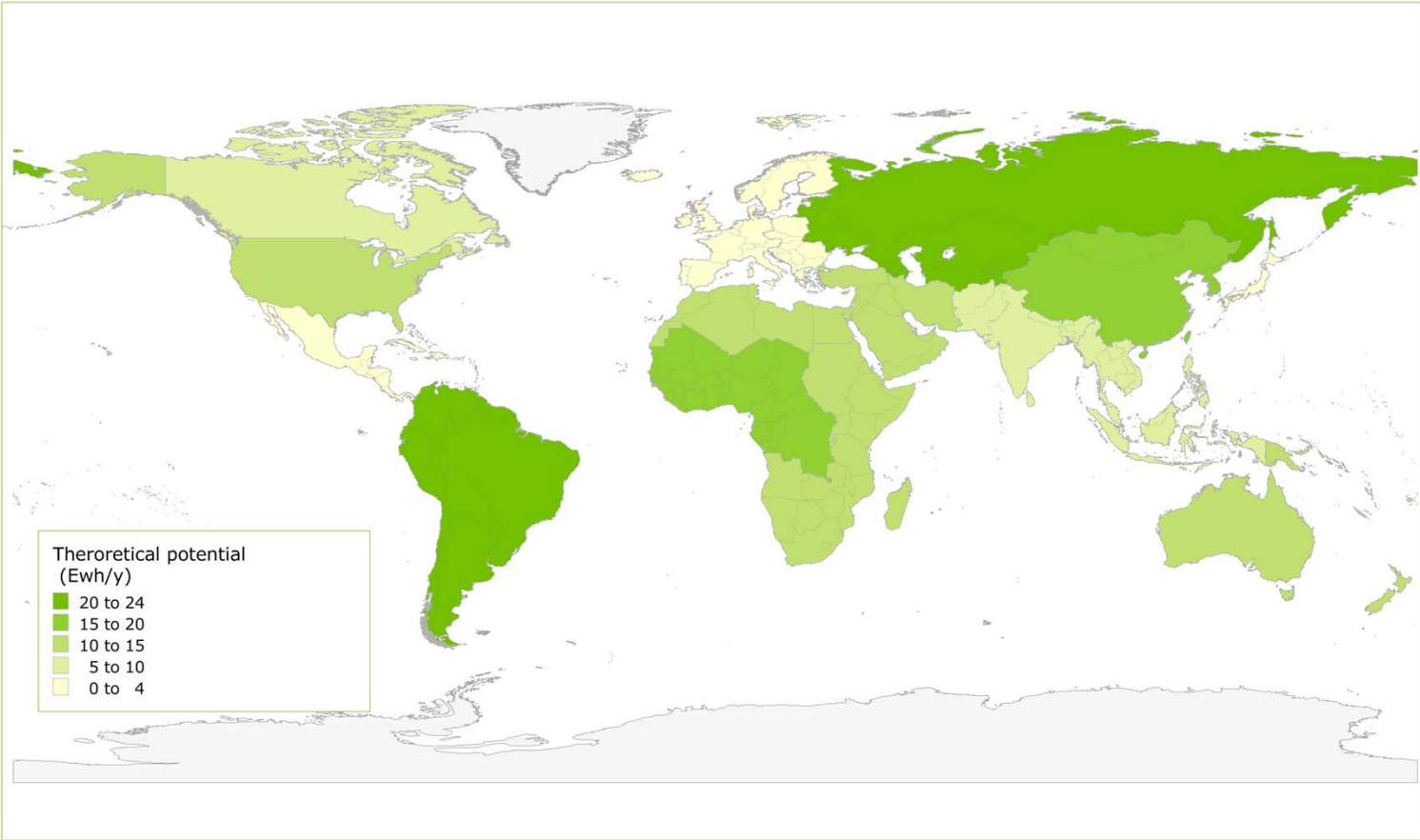


RE Potentials

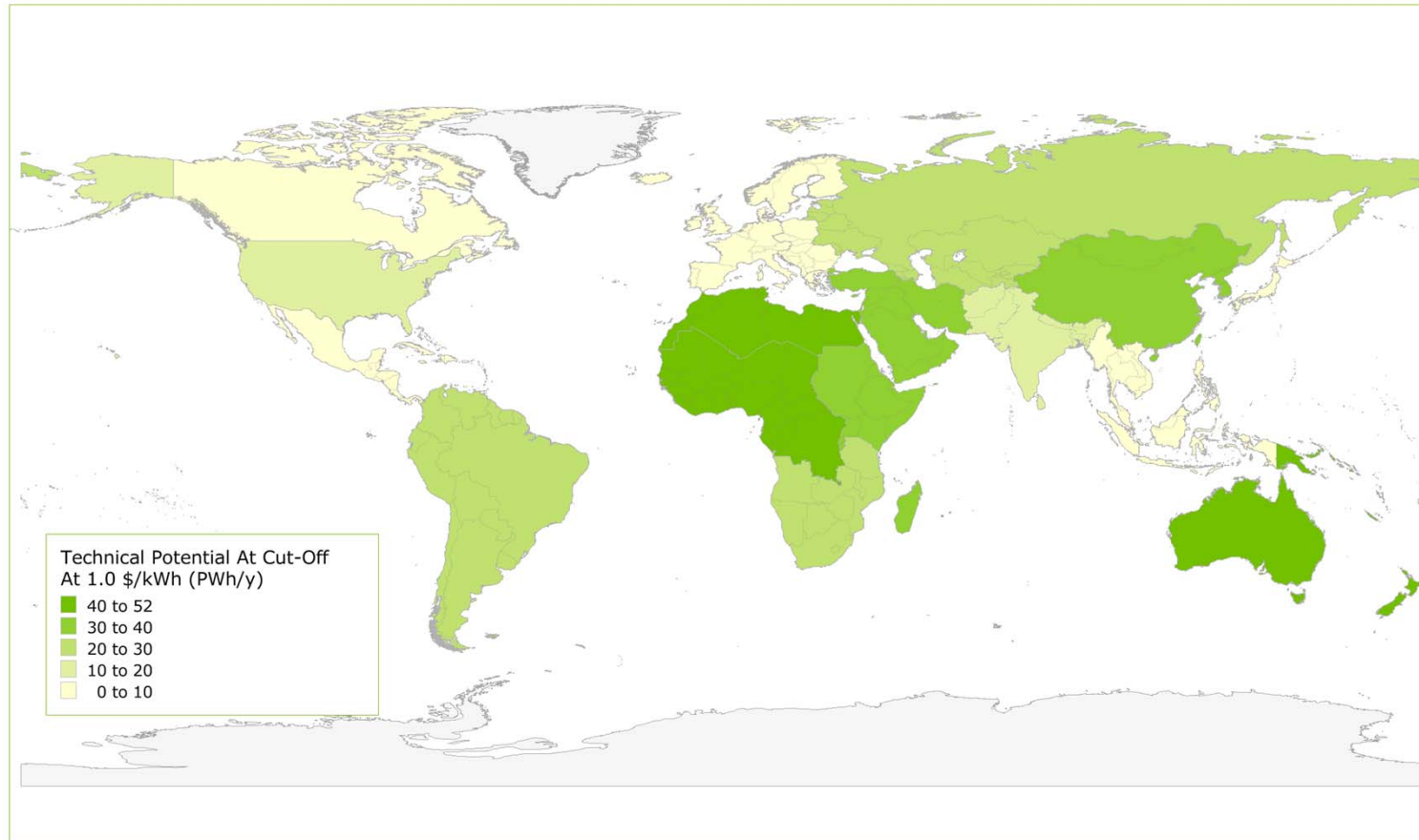
	Snapshot of wind energy potentials for Europe in 2030	Definitions of potentials	Progression criteria	
Theoretical	~1,400,000 TWh/year (2,200 mb/d) ^[1]	Physically recoverable energy from sun, wind, earth, biomass over a certain time span in a given region, defined solely by the physical limits of use	Climate change Land use change	<p>RE proxy for fossil contingent resources</p> <p>RE proxy for fossil reserves</p>
Technical	75,000 TWh/year (120 mb/d) ^[2]	Fraction of the theoretical potential that can be used under the existing technical restrictions (currently available technology)	Technology developments	
Economic	30,400 TWh/year (50 mb/d) ^[2]	Fraction of the technical potential that can be economically recovered within the actual energy system (competitive costs). Various approaches exist to assess the economy of a RE technology	Economic competitiveness with conventional energy sources	
Implementation /Deployment	1,200 TWh/year (~2 mb/d) ^[3]	Fraction of the economic potential that can be deployed under realistic conditions (non-economic barriers)	Removal of non-economic barriers (social acceptability, grid integration, etc)	

Sources:
 [1] Hoogwijk, 2004 and own calculations
 [2] EEA, 2009
 [3] Green-X, 2012

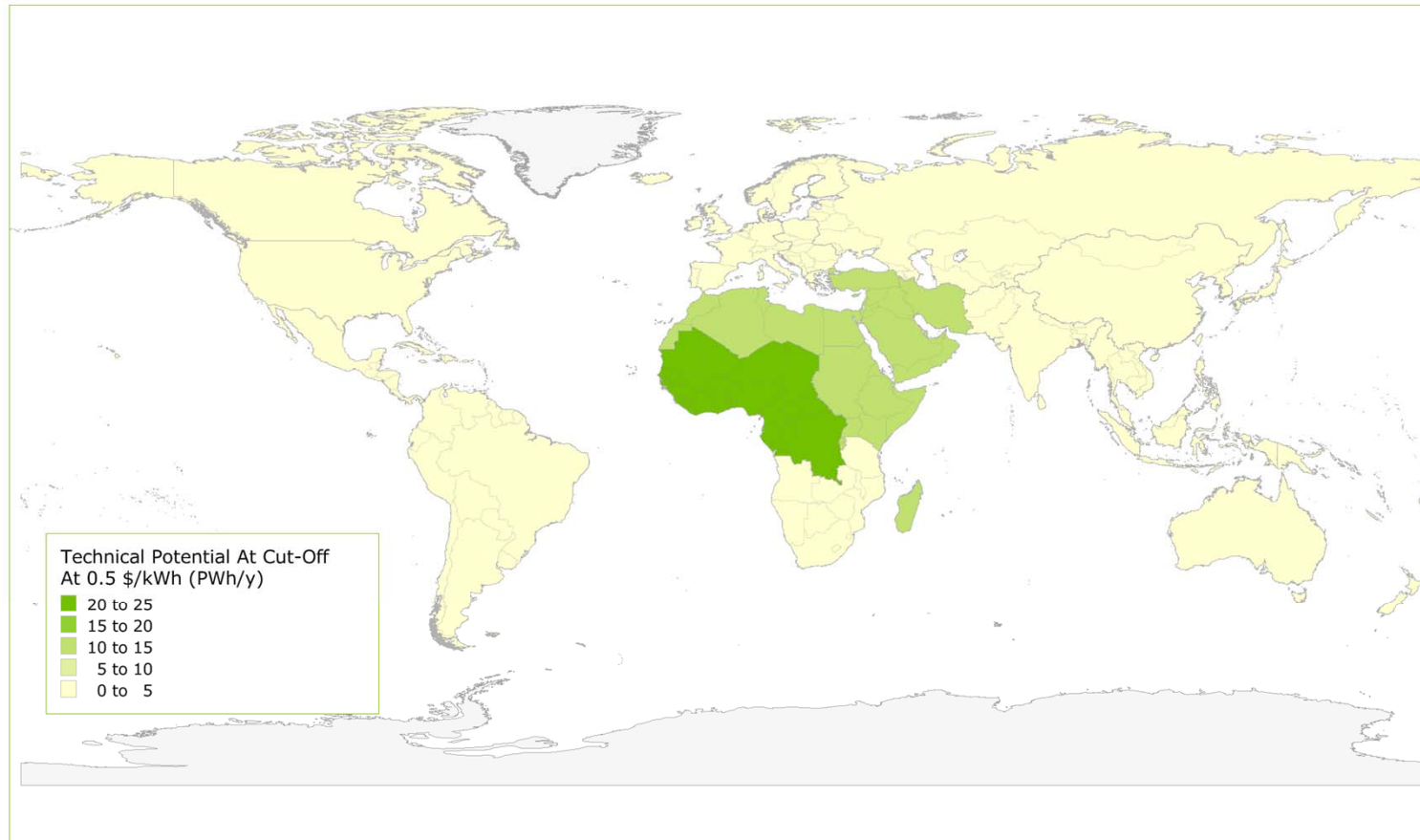
Global solar potential

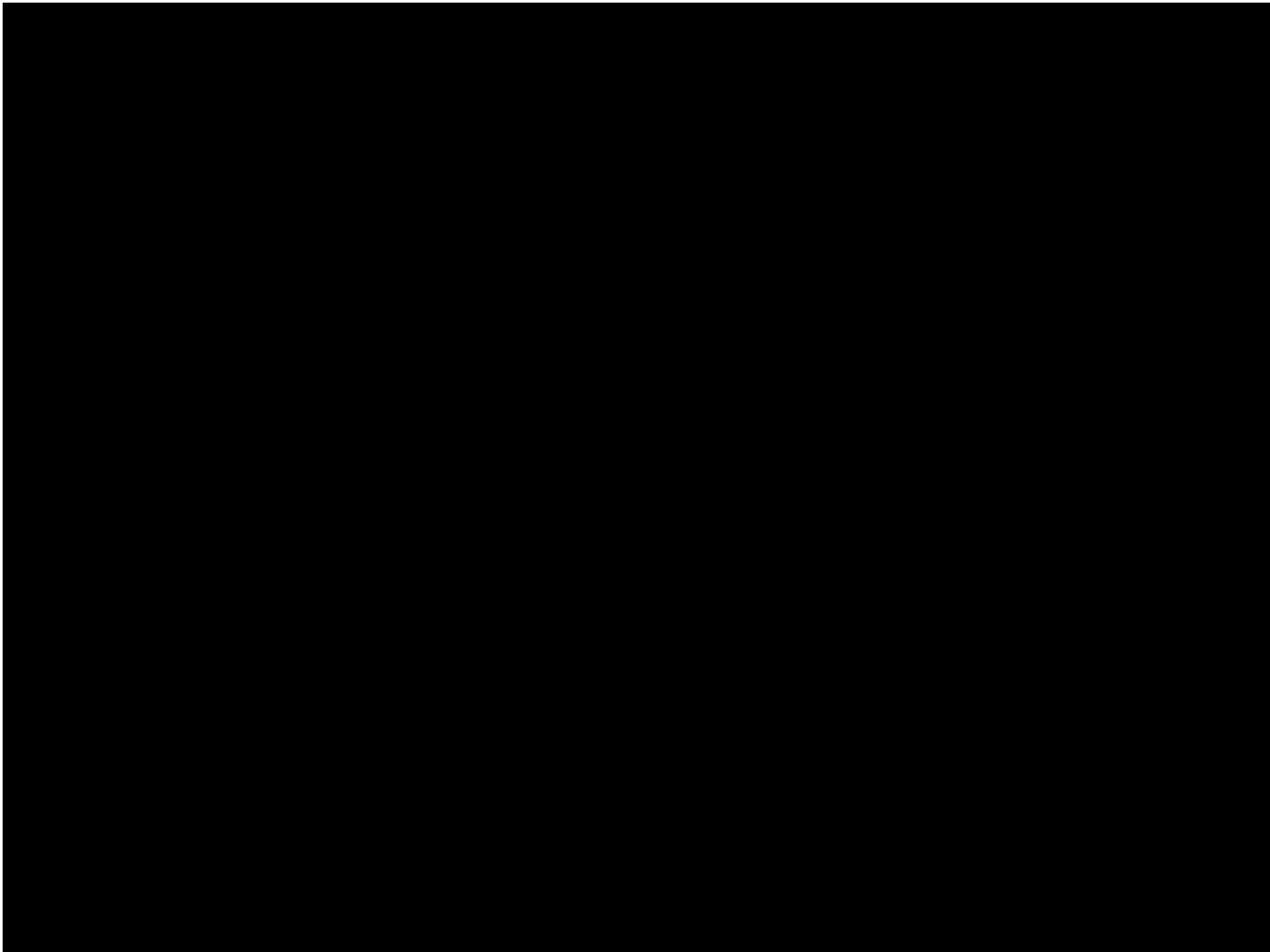


Global solar potential



Global solar potential


















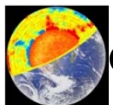

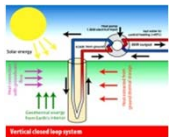



Comparison renewable energy and oil and gas projects

> Time horizon

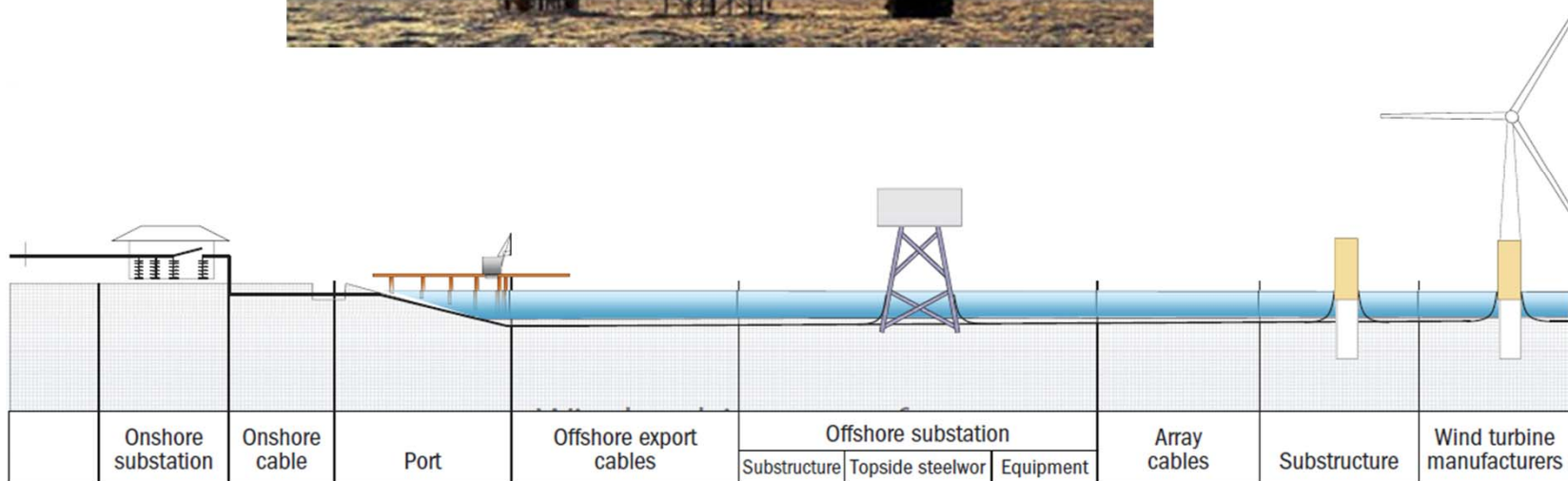
> Asset scope

> Energy system equivalence

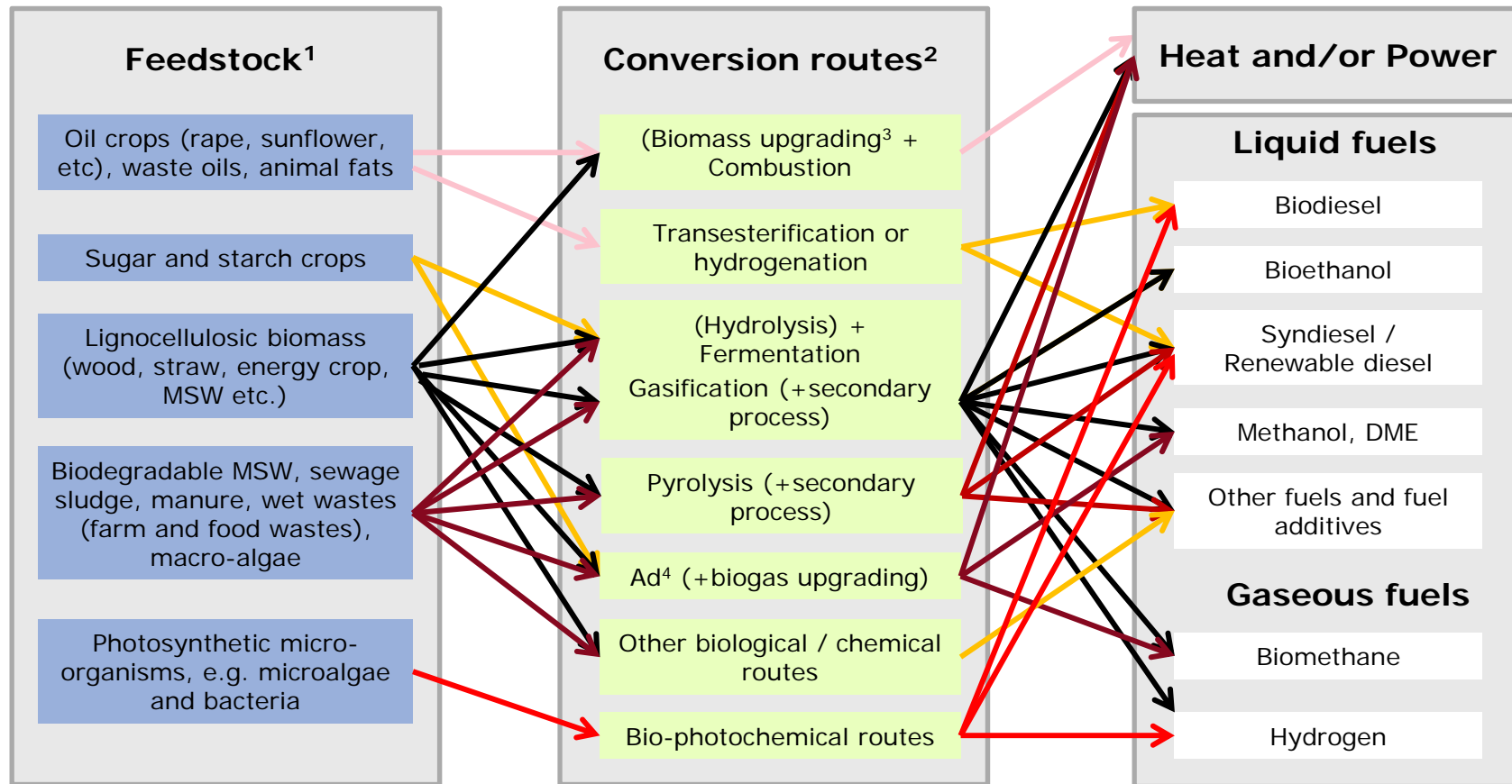
Time Horizon

	Resource availability	Land lease	Equipment	Contract for feedstock	Market
 <p>Biofuels</p>					
 <p>Wind and solar power</p>		 	 		
 <p>Geothermal</p>					 

Asset scope (1)



Asset scope (2)



¹Parts of each feedstock, e.g. crop residues, could also be used in other routes

²Each route also gives co-products

³Biomass upgrading includes any one of the densification processes (pelletisation, pyrolysis, torrefaction, etc.)

⁴AD = Anaerobic Digestion

Sources: Synthetic view of the wide variety of bioenergy routes. Bioenergy – A Sustainable and Reliable Energy

Source: Main Report. IEA. Bioenergy:ExCo:2009:06 (<http://www.ieabioenergy.com/LibItem.aspx?id=6479>).

Asset Scope (3)

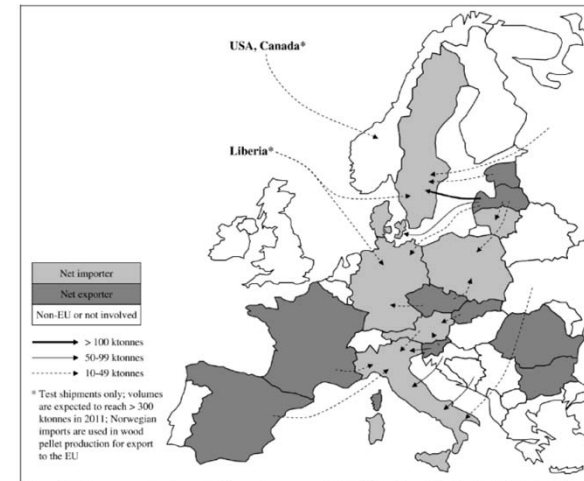
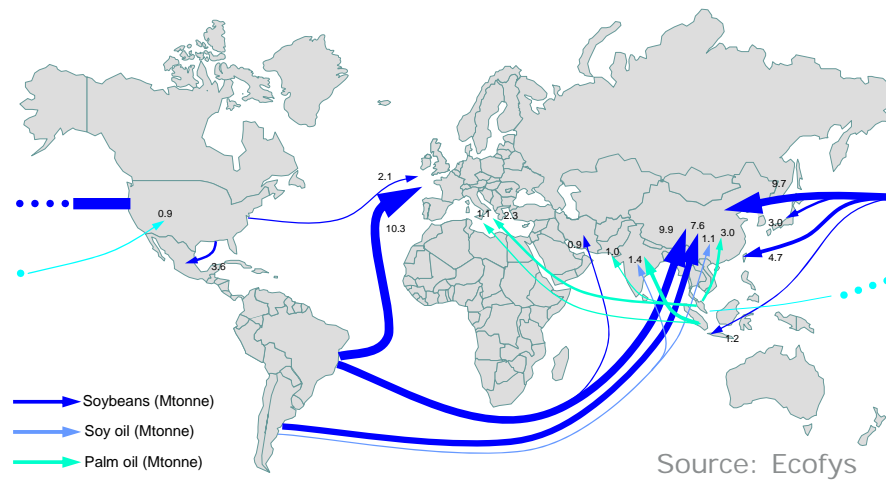
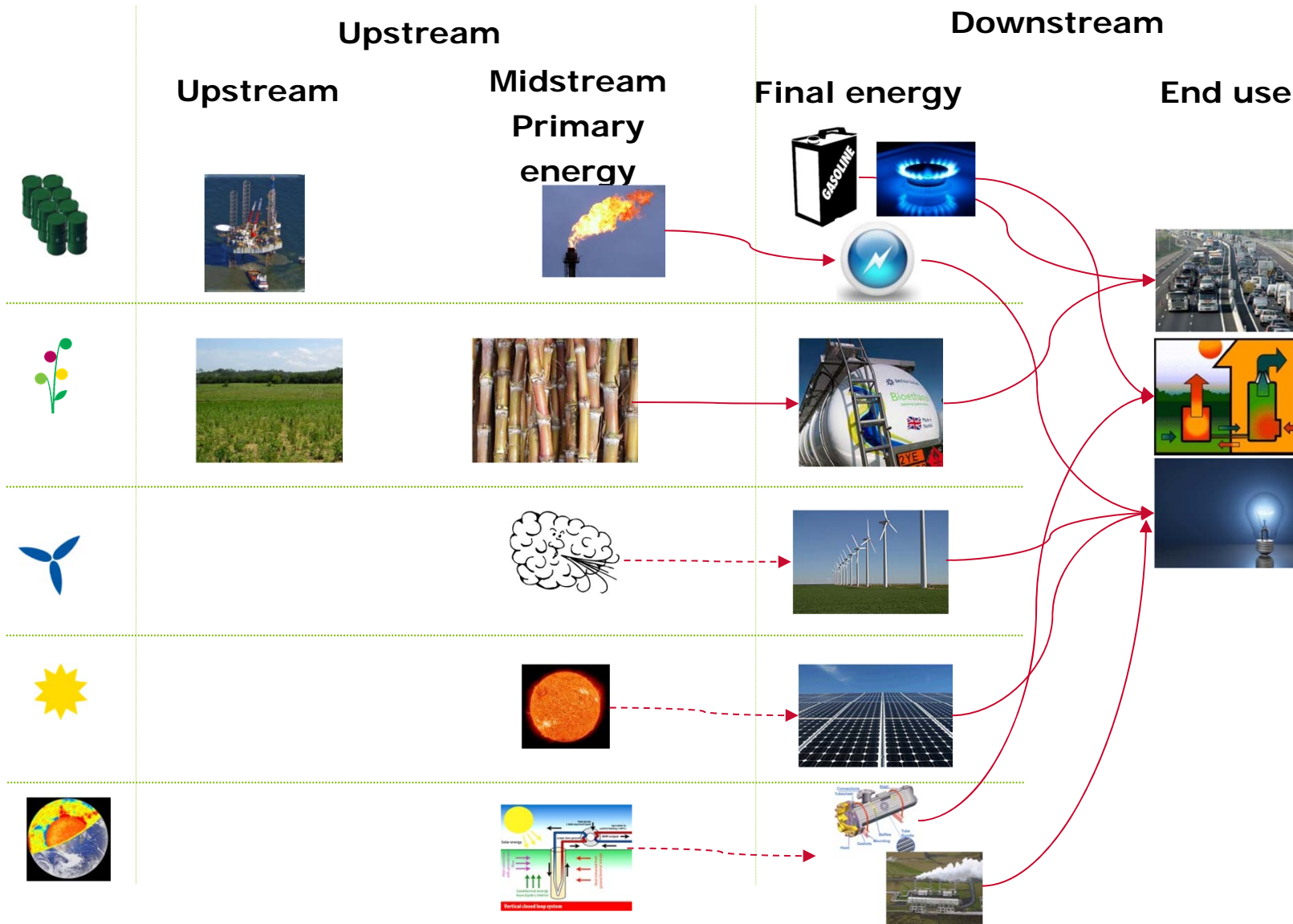


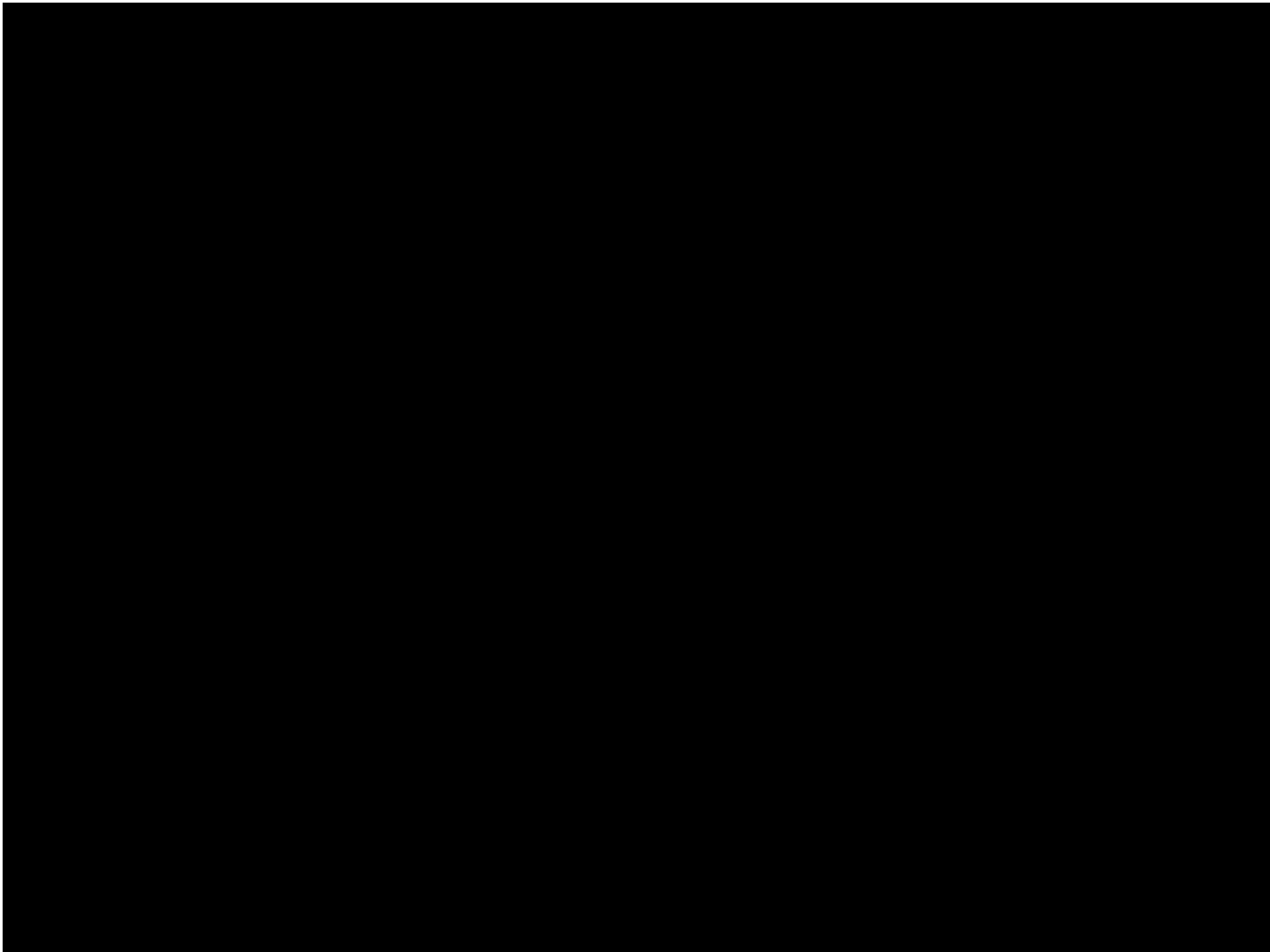
Figure 5. Bioenergy related wood chip trade patterns in 2010 based on [20, 27, 28, 40, 57, 60-62]
 Note: Trade streams towards Denmark, Germany and Sweden are also indicators for roundwood trade volumes and routes.

global trade flows of vegetable oils and oilseeds



Energy system equivalence





Conclusions

- > Global resources in renewable energy are significant
- > There is no exact definition of potential for renewables
- > Differences in certain elements of projects \Rightarrow important in reserve concept