Future demand for ecosystem services from terrestrial ecosystems from global power production scenarios to 2100

the role of forest biomass

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Future demand for ecosystem services from terrestrial ecosystems from global power production scenarios to 2100: the role of forest biomass

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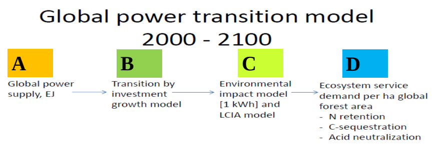
Access to electricity is one of our main sustainability challenges, but don't let the energy sector run our forests – take advantage of the fuel demand and build healthy forests for the future

Take home message: We can **increase electricity production** for human needs in many ways using renewable and non-renewable energy technologies. All have **negative** environmental **impacts**. Transition is **slow**.
In order to share **limited resources** we will need to **change life styles** and substitute some of our current consumption to products and activities with less environmental impact.
Adaptive sustainable forest management is the key to the future. Income from **bioenergy supply can help the forest to adapt** to global environmental change .
With bioenergy, forests can be managed for health and for fire risk reduction in fire-prone areas.
Forestry is longterm so protect soil nutrient capital and **recycle** nutrients in **bioash** if possible.

Electricity distribution started in the 1880ies in the metropoles London and New York.
Globally, 90-94% of the population now (2009) have access to electricity in urban areas. In developing countries 1.3 bn people many in rural areas, have no access to electricity (WEO, 2011).



A. Current production of electricity and future scenarios

From 2005: 65 EJ electricity for a 7 bio. world population is 2600 kWh cap^{-1} $year^{-1}$.

To 2100: 160 EJ for 10 bio capita is 4400 kWh cap^{-1} $year^{-1}$.

B What are the scenarios ?

1. Renewable: Coal and other fossil is reduced by 2% p.a., and forest renewables increased by 8% p.a. Emphasis on bioelectricity. Other change rates -2% to 6% p.a. Slow increase to 2040 due to efficiency gain efforts.

2. Efficiency (land): Coal is increased by 2% p.a. Other tech's should be land ressource efficient (e.g. wind, solar). No increase in bioelectricity from forest. Other change rates -2% to 3% p.a.

3. Fossil: Electricity production increases by increases in fossil and renewable tech's. Change rates -1% to 2% p.a.

Sustainable cities are electrified
Electricity can support **education, health care, water supply and mobility** and promote air quality in peoples homes. Electricity access is a prerequisite for sustainable development in the urbanized world.
Other assumptions:
- Over time the most suitable land is allocated to food production and non-food by-products.
- The current size of the agricultural area will provide the necessary food. Diets will change accordingly.
- Tropical deforestation will stop after a further loss due to lack of efficient forest policies. Here up 76 mio ha can be deforested.

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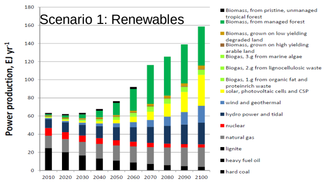
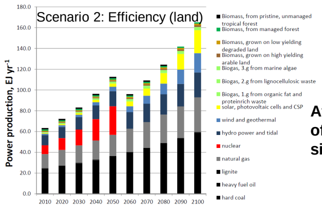
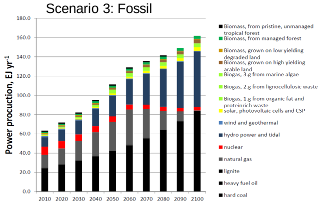
B. Power production – transition by investment

$$Power\ production_j = \sum Technology_i \times (1 + r_i - d_i)^{(j-2010)}$$

$$for\ Power\ production_{ij} < Potential_i;\ else\ 0\ (non-renewable) \ or\ Potential_i\ (renewable)$$
$$where\ i\ is\ technology; j\ is\ decade\ up\ to\ 2100$$





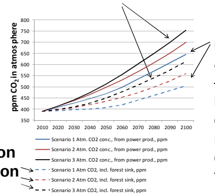


Global electricity mix start values from the year 2005 (WEO). Solar and bioelectricity start values are set to 0.5 - 2% (<<1% in 2005).

C. Environmental impacts

CO_2 emissions from biofuel are treated 'brutto' as they **are** emitted into the atmosphere.
The carbon sink is the uptake in forest ecosystems:
$dCO2_{atm}$= CO_2 emission (all energy) – forest growth ~ 8 m^3 ha^{-1} yr^{-1} (~ assumed global average for forest).

Fossil: Will the forest sink be declining due to climate change?

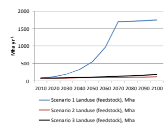


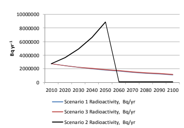
Renewable: Intense use of solar, wind and biomass power – a larger share of biogenic C in emissions **and** a more healthy, climate adapted forest (?)

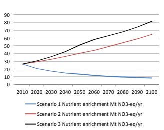
After deduction of forest carbon sink !

Emission factors were adapted from the Ecoinvent 2.0 database and the LCIA EDIP (1997). They include every use of materials and energy and emissions related to 1 kWh from cradle to gate. These factors will change over time, but serve the purpose of this simple model.
The forest production should be rainfed and represent near-natural water balances.

More impacts: Land use, radioactivity and nutrient enrichment







1. Renewable

2. Efficiency (land)

3. Fossil

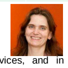
D. Demand for ecosystem services - provisioning and regulating

Wood for energy.
Carbon sinks due to burning of fuels (bio and fossil).
N retention in ecosystems caused by N deposition from burning of fuels for electricity.

Forest fuel can be nitrogen negative
The demand for N retention from energy production is levied on forests due to the strong crown filter effect. Biofuel utilisation may slow down N saturation in high emission areas.
NO_x can be filtered out of the smoke at the combustion plant.

Soil buffering of acidifying substances due to harvest of biomass and air pollution.

Provisioning and regulating ES		**1. REN**	**2. EFF**	**3. FOSSIL**
High yield land, % of arable land (2000) by year 2100	%	0.5	1.1	2.8
Degraded land, % of arable land (2000) by year 2100	%	10	4	2
Forest land, % of forest area (2000) by 2100	%	42	1	3
TOTAL ES required next 100 years from electricity production				
Soil Acid Neutralizing Capacity (ANC)	$kmol_+\ ha^{-1}$	20	59	71
Climate regulation	$t\ C\ ha^{-1}$	355	425	494
Uptake of reactive Nitrogen	$kg\ N\ ha^{-1}$	82	254	309
Required forest growth per year	$m^3\ ha^{-1}\ yr^{-1}$	14	17	20
Base cation removal in 2100 (BC: 2 mg/g in stem wood)	$Mt\ yr^{-1}$	13	1	2
Phosphorus removal in 2100 (P ~ 0.05 mg/g in stem wood)	$Mt\ yr^{-1}$	0.4	0.04	0.06



Presenter biography:
Ingeborg Callesen, Ph.D. Forest ecology, M.Sc. (forestry)

Ingeborg's research in forest ecosystems and their services, and in sustainability related with forestry has been carried out at Forest and Landscape Denmark (1996-2006), Risø (2007-10), DTU Management Engineering and Risø-DTU (2010-12), and at the University of Copenhagen (Forest and Landscape Denmark, now a part of Department of Geosciences and Natural Resource Management) (2012-.
Until 2006 Ingeborg specialized in forest soil science and forest ecology (tree growth, phenology, pedology, physical and chemical soil properties including natural abundance of the stable ^{15}N isotope, forest site classification), and statistical modeling using soil databases and national inventory data. Main subjects were carbon storage and nitrogen storage as related to macro climate and inherent soil fertility, nitrate leaching from forest ecosystems, and management aspects of bioenergy including bioash application and assessment of biomass potential.
In 2007 Ingeborg included sustainability science in her research portfolio putting focus on the bioenergy sector in a cross disciplinary team work including environmental and energy economics. The work with sustainability assessment (2007-) has led to the insight that interpretation of systems are linked to the world views and nature views incorporated in them. It may imply the existence of parallel knowledge and paradigms.