



Our Energy Future

**ANALYSIS OF THE IMPACT OF LARGE
BIOMASS ON THE ENERGY MIX IN
BELGIUM**

Context and objective of the study

- Recent **policy decisions** in Belgium to increase the amount of biomass within the energy mix
 - The objective is to reach the national renewables target of 13% by 2020
 - Flanders: two plants are being scheduled
 - Ghent: BEE power plans the construction of a new 215 MW biomass plant
 - Langerlo: German pellets plans the refurbishment of an old coal fired plant to a biomass plant of approximately 500 MW
 - Wallonia: one plant is being scheduled
 - New Walloon government has the intention to support a biomass plant of approximately 200 MW



The objective of this study is to quantify the impact of these policy decisions in terms of required investments, Levelized Cost of Energy (LCOE) and subsidies

* European Commission, VEA, Bee.eu, rtbf, Assumption minimum support of 93 EUR/certificate, Ontwerp van Ministerieel besluit houdende vaststelling van een voorlopige bandingfactor voor de biomassa-installatie "BEE Power Gent", Ministerieel besluit houdende vaststelling van een definitieve bandingfactor voor het "conversieproject Langerlo"

Wood pellets as feedstock

- The biggest plant in Langerlo (German pellets) will only use wood pellets as feedstock
 - German pellets has production plants in Europe but the company has recently opened production sites in the USA so it can be expected that additional demand will be sourced from these plants:
 - Pellet plant in Woodville, Texas, reached full capacity in 2014
 - Pellet plant in Urania, Louisiana, was commissioned in early 2015 and is gradually increasing its production capacities
- Our assumption is that the plant in Ghent (BEE) will mainly use wood pellets as feedstock
 - There are no detailed figures related to the exact feedstock mix publicly available in the environmental impact report or in other sources
- There is currently no information available related to the feedstock for the plant in Wallonia but it is probable that mainly wood pellets will be used as in the two other plants

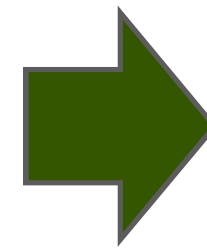


Our assumption is that all plants will use wood pellets as feedstock

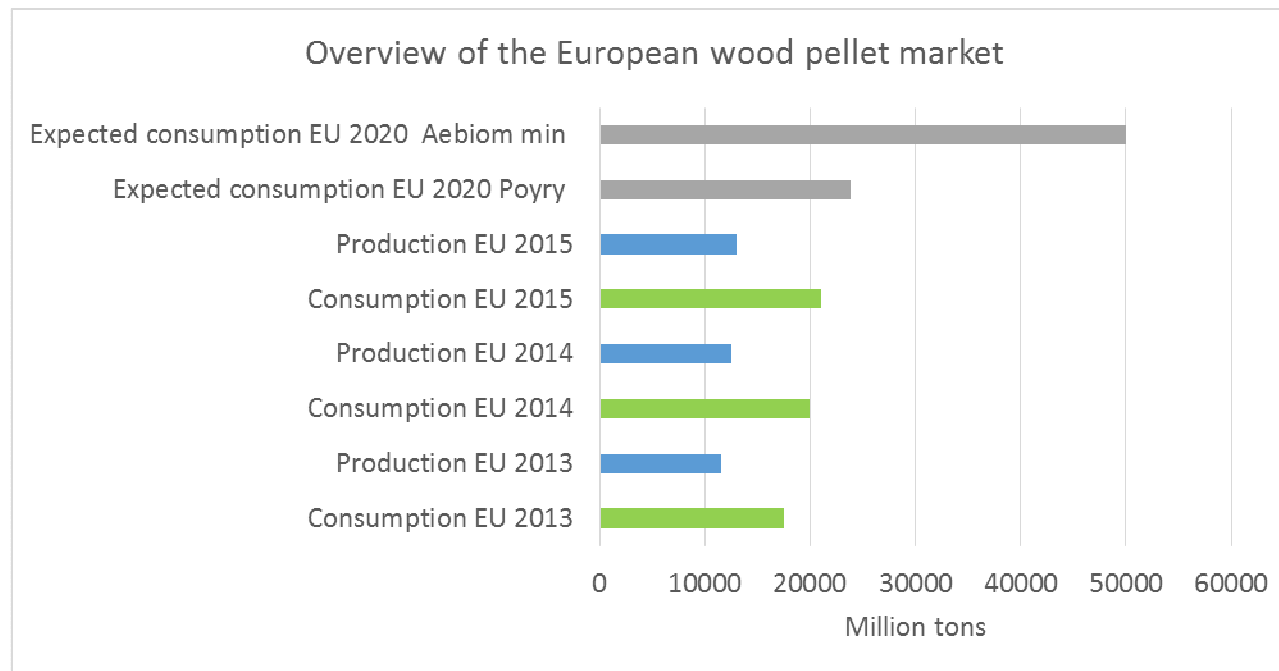
* VEA, Deredactie, Bee.eu, biomassmagazine.com (<http://biomassmagazine.com/articles/11956/german-pellets-reports-strong-2014-startup-of-louisiana-plant>), Niet-technische samenvatting milieueffectenrapport Biomassa-elektriciteitscentrale BEE Power Gent

The industrial wood pellet market in Europe

- Europe is by far the largest consumer of wood pellets in the world: industrial demand and primarily power generation
- Demand is expected to strongly grow:
 - National Renewable Energy Action Plans EU-27
 - National initiatives UK (Ex. Drax 7,5 million ton/year)



Large industrial demand mainly driven by policy

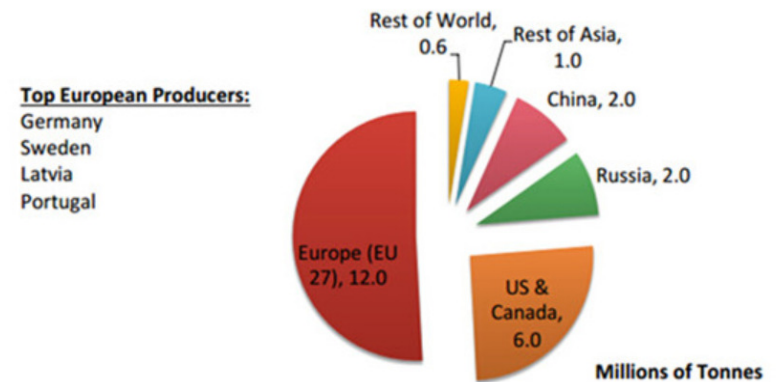


* The European Biomass association (AEBIOM), FAS Post Estimates, Pöyry Management Consulting, Office of Industries of the US International Trade Commission, Renewable Energy World, EC

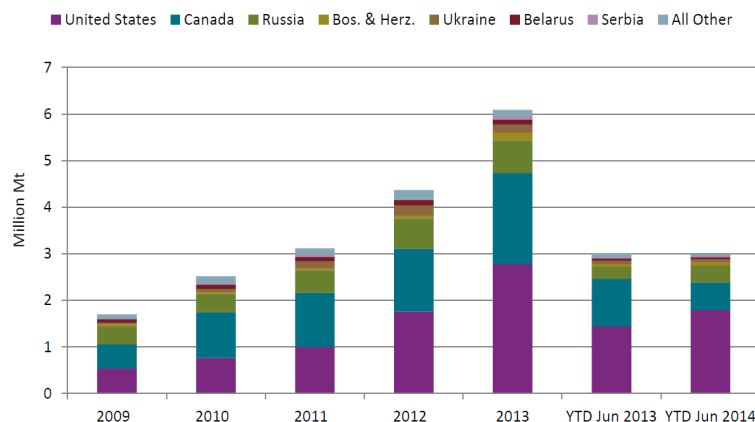
Increasing imports from US Southeast expected

- Although Europe has the largest pellet production capacities in the world and will remain an important player, there is a limited surplus biomass to allow for additional supply
- In Europe, biomass can only be used in a sustainable way to reach the 2030 targets if we significantly reduce energy consumption and use woody residues

Global regional pellet production 2013



EU wood pellet imports by supplying countries



- Growing demand will increasingly be satisfied by imports from other regions, Belgium is already one of the biggest importers and is expected to continue to be in the coming years
- The US accounted for the largest part of wood pellet imports to the European Union in 2013-2014

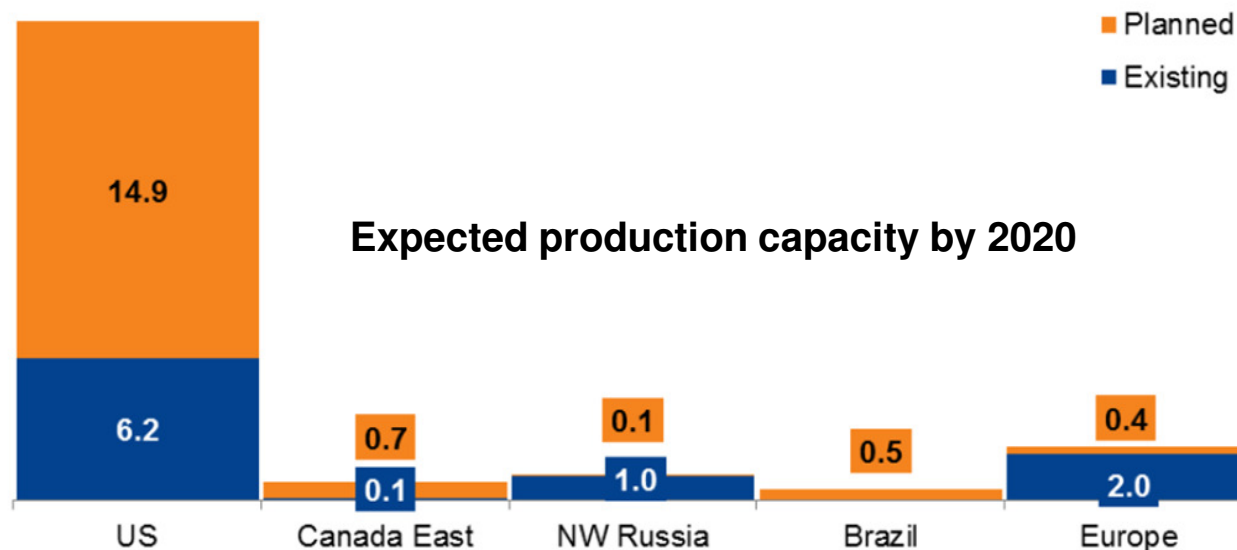
* Wood Pellet Global Market Report 2014 (retrieved from <http://www.biofuelmachines.com/wood-pellet-global-market-report-2014.html>), International Institute for Sustainability Analysis and Strategy, European Forest Institute and Joanneum Research, Pöyry Management Consulting, Ekman&Co, IEA, Office of Industries of the US International Trade Commission, YTD= Year To Date (from January to June)

Increasing imports from US Southeast expected

- US is not only the most important exporter to Europe
- The **US Southeast** also:
 - Offers the most attractive combination of biomass supply, cost structure, infrastructure and investment climate
 - Has already planned a lot of capacity



Europe will mainly source biomass from this part of the world in the short to medium term



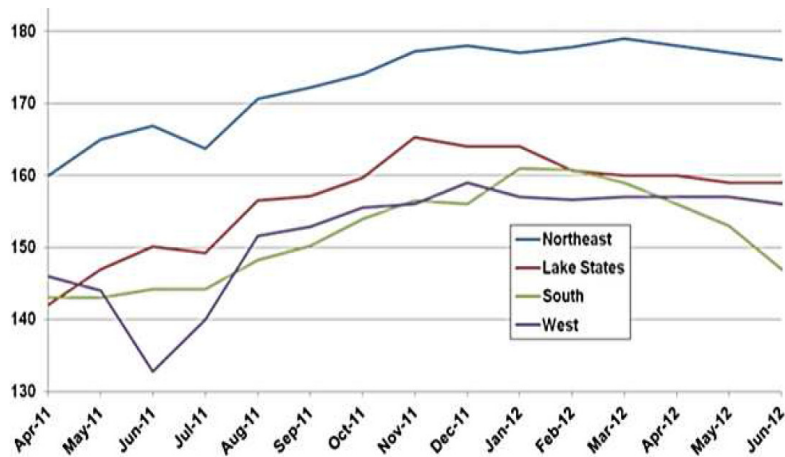
* Pöyry Management Consulting, Ekman&Co, IEA, Office of Industries of the US International Trade Commission

Main price drivers of wood pellets from the US

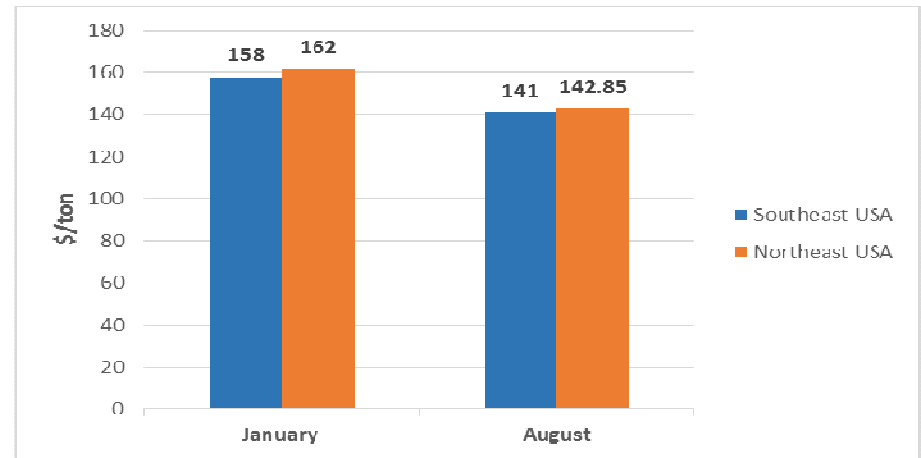
- **Raw material:**
 - Availability and quality of feedstock
- **Seaborn transport:**
 - Large-scale imports from North America are usually delivered to Europe in Handymax vessels (45 000 tonne) or Panamax vessels (60 000 to 80 000 tonne)
- **Capital expenditures:**
 - Mainly pelletising in mills
- **In future sustainability criteria and caps on biomass production?**

Stable wood pellet export prices in recent years

US FOB export price 2011- 2012 in \$/ton (Walker)



US Fob export price 2015 in \$/ton (Argus biomass)



Prices include all costs until the port of origin in the US:

- Feedstock (raw material), treatment in mills (capital expenditures), transport to port of origin, storage and loading/unloading in the port of origin
- Logistics from port of origin to end user are not included
- Our assumption for pellet export prices 2015 is **160\$/tonne**

* IEA, Walker, Argus biomass (own contacts with traders), NREL, Pellet.org

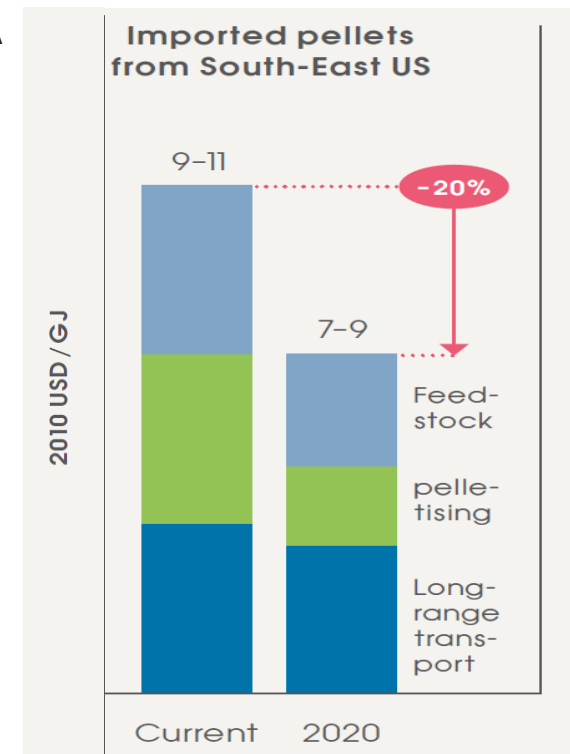
Costs of wood pellet logistics

- Larger volumes lead to lower rates and port facilities are more and more prepared for large volumes
- **Freight costs** will have to be borne by the **buyer of wood pellets**
 - Transport from USA to port of Antwerp or Rotterdam (ARA (Antwerp or Rotterdam)-region)
 - Freight costs for Panamax ocean vessels (85 000 tonnes) in general are estimated to be around 17 USD /tonne in 2014
 - On 26/08/2015, freight rates from Mobile (USA) to the ARA region were 20,10 USD/tonne for a 45 000 tonne vessel
 - Our **assumption** for the model will be **20 USD/tonne**
- **Transport from ARA- region** to end user (Ghent, Langerlo) will have to be borne by the **buyer of wood pellets**
 - Transport to end user is between 2% and 10 % of the end user price
 - Our **assumption** for the model will be **5%** because large volumes lead to the lower bound of this range

Price forecasts for wood pellet prices from US

Different price forecasts available:

- For 2016-2018, the export price for wood pellets (without costs from port of origin) was forecasted between 148 USD/tonne and 168 USD/tonne on **26/08/2015** (Argus Biomass)
- The total cost of feedstock, pelletising and long range transport from US South-East to Europe is expected to go down by 20% between **2012 and 2020** (IRENA and European Climate Foundation)
 - Mainly because of lower cost of pelletising
 - 11 USD/GJ corresponds to 193 USD/tonne
 - 9 USD/GJ corresponds to 158 USD/tonne
- The market price of wood pellets is expected to be around 180 USD/tonne between 2017-2022 and drop to around 160 USD/tonne by 2027 (Pöyry)



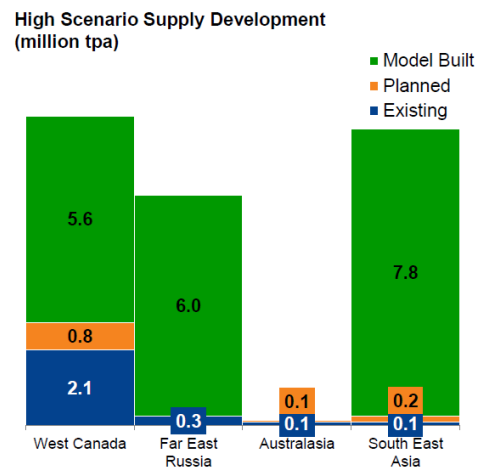
* Argus Biomass (own contacts with traders), European Climate Foundation, Pöyry Management Consulting, Wood Pellet Association of Canada

Price forecasts for wood pellet prices worldwide

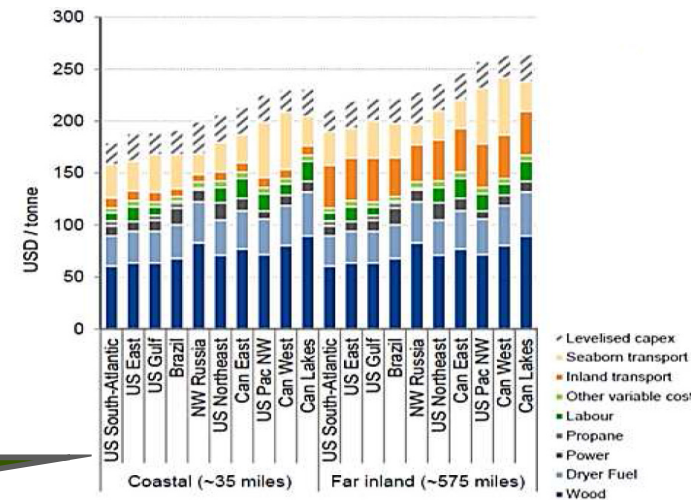
However:

- If demand in UK, The Netherlands, Belgium and other (non-European) countries increases significantly, additional capacity will have to be sourced from other regions than the US
- **This might lead to higher prices because these regions have a less interesting cost structure**

MW pellet supply development in case of high demand



Pellet supply cost breakdown ARA region



Our assumption for imports to Europe is a price increase of 1% per year because market evolutions are highly uncertain

1. Same assumption as for small case biomass in the reference scenario
2. Discussion biomass trader confirms that prices in others regions than USA are higher
3. Uncertainty reveals the need for sensitivity analysis (further)

* IEA Bioenergy, Argus Biomass (own contacts with traders), Pöyry Management Consulting



Assessment of large biomass in Belgium by leveraging the existing energy model

- Assumptions for a standard large scale biomass plant
- Different scenarios for large scale biomass in Belgium
- New scenarios for wind and solar PV with large scale biomass
- Results for different scenarios
- Sensitivity analysis

Assumption for standard large scale biomass plant (new tab in sheet “investment model)

Parameters	Assumptions for standard large scale biomass	
	Value	Sources
Exchange rate USD/EUR	1,33	European Central Bank (01/01/2010-31/12/2014)
WACC	10%	IRENA, IEA, VGB Powertech
Installed capacity reference installation	215 MW	
Bee Gent	215 MW	VEA, Energeia
Langerlo	519 MW	VEA
Wallonia	215 MW	Rtbf
Date operational		
BEE Gent	01/01/2019	VEA
Langerlo	01/01/2017	VEA
Wallonia	01/01/2020	Own calculations
Hours operational	7500	IRENA, IEA, VGB Powertech
CAPEX/MW (weighted average of values)	800 000 euro	Bee.eu (BEE Gent), Energeia (Langerlo), Wallonia (assumption same as BEE Gent)
Operation period	30 years	IRENA, VGB Powertech, NREL
O&M	5%	IRENA, VGB Powertech, Decarboni.se
Support period (weighted average of values)	12 years	VEA (BEE Gent), VEA (Langerlo), Wallonia (assumption same as BEE Gent)
Electrical efficiency	35%	Intelligent Energy Europe, European Commission, VGB Powertech
Thermal efficiency (heat recovery)	8,50%	Half of maximum efficiency BEE Gent
Construction time	3 years	Bloomberg New Energy Finance EPVAL document,
Federal Investment deduction	13,50%	Agentschap ondernemen
Offtake	0%	Own assumption
Market price wood pellets US	189,5 \$/ton	160 (pellet export price)+20 (freight)+ 5/95*180 (5%)
Yearly increase market price wood pellets	1%	Own assumption

*The environmental license applications mention a net electrical efficiency of 41% for BEE and 37-39% for Langerlo. Since this efficiency highly depends on the feedstock and technology that will be used, we use external sources for the standard plant and perform sensitivity analysis (further)

**The environmental license applications mention a thermal efficiency of 17% for BEE and 0% for Langerlo. However, BEE still has to find markets for this heat so there is a lot of uncertainty. We choose half of the capacity BEE Gent for the standard plant and perform sensitivity analysis (further)



New scenarios for large scale biomass in Belgium (EnergyBalanceModel)

Different scenarios for large scale biomass

1) Scenario all plants operational

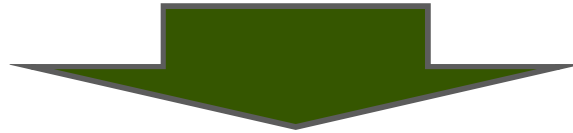
2) Scenario only Langerlo and BEE

3) Scenario only Langerlo

4) No biomass

New scenarios with large scale biomass

- More large scale biomass in the energy mix = less onshore wind, offshore wind and/or solar PV
 - Our objective is to have the same GWh production over the period 2014-2050 as in the Greenpeace-BBL-WWF scenario (further “alternative scenario”) of the initial study
 - How much onshore wind, offshore wind and/or solar PV will be installed with more large biomass in order to produce the same GWh?



New scenarios in the model for onshore wind, offshore wind and PV solar

New onshore wind scenarios to compensate for more large scale biomass

New scenarios for onshore wind
1) Medium scenario (initial study)
2) High scenario (initial study)
3) No growth (initial study)
4) FOD Prosp. 2014 - Nuc 1800 (initial study)
5) Biomass scenario all plants operational compensated by less onshore (new)
6) Biomass scenario only Langerlo and BEE compensated by less onshore (new)
7) Biomass scenario only Langerlo compensated by less onshore (new)
8) Biomass scenario all plants operational compensated by less onshore (50%) and other technology (offshore, PV) (50%) (new)
9) Biomass scenario all plants operational compensated by less solar PV (33%), wind onshore (33%) and wind offshore (33%) (new)

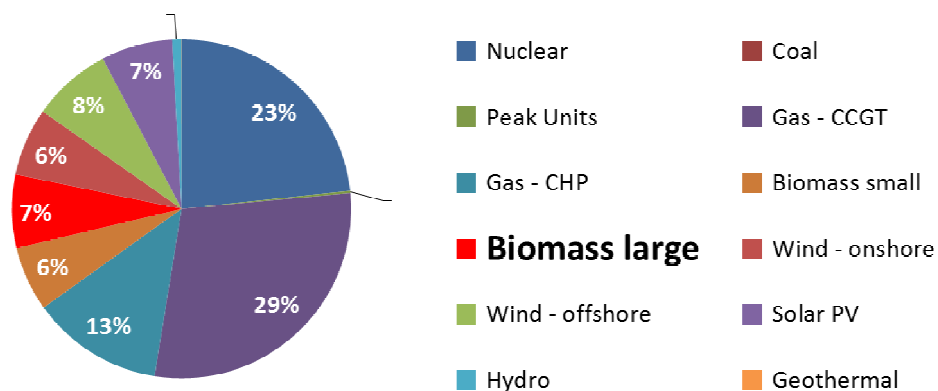
New solar PV scenarios to compensate for more large scale biomass

New scenarios for PV solar
1) Medium scenario (linear) (initial study)
2) Medium scenario (non-linear) (initial study)
3) High scenario (linear) (initial study)
4) FOD Prosp. 2014 - Nuc 1800 (initial study)
5) Current capacities, no future growth (initial study)
6) High scenario (non-linear) (initial study)
7) High scenario (non-linear 2) (initial study)
8) Biomass scenario all plants operational compensated by less solar PV (new)
9) Biomass scenario only Langerlo and BEE compensated by less solar PV (new)
10) Biomass scenario only Langerlo compensated by less solar PV (new)
11) Biomass scenario all plants operational compensated by less solar PV (50%) and other technology (50%) (new)
12) Biomass scenario all plants operational compensated by less solar PV (33%), wind onshore (33%) and wind offshore (33%) (new)

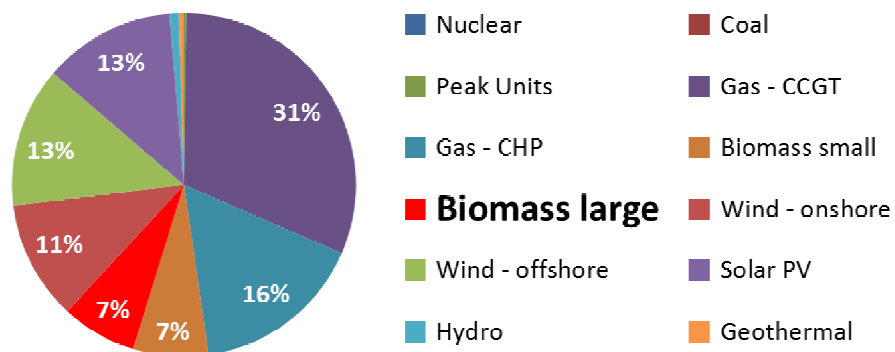
Results

- If all large biomass plants are operational, 7% large biomass in energy mix by 2020 and 2030

Energy mix (%) - 2020



Energy mix (%) - 2030



Results

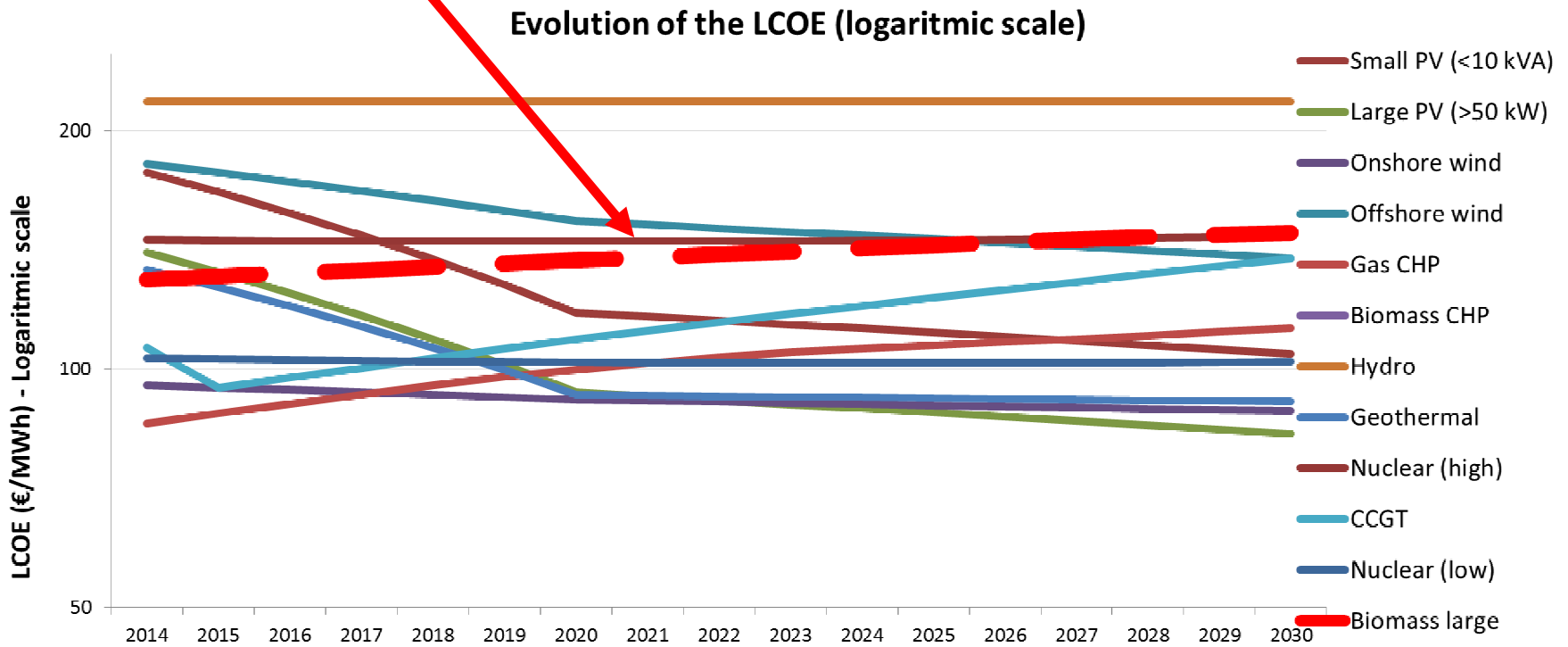
- If all large biomass plants are operational, 20% large biomass in renewable energy mix by 2020 and 13,5% large biomass in renewable energy mix by 2030

2020	GWh production	%
Biomass small	6258	17.65%
Biomass large	7117	20.08%
Wind - onshore	6599	18.61%
Wind - offshore	7700	21.72%
Solar PV	6911	19.50%
Hydro	863	2.44%
TOTAL	35448	100%

2030	GWh production	%
Biomass small	7128	13.66%
Biomass large	7118	13.64%
Wind - onshore	11288	21.63%
Wind - offshore	13300	25.48%
Solar PV	12491	23.93%
Hydro	864	1.65%
TOTAL	52188	100%

Results

- LCOE for large biomass is increasing while LCOE for other technologies such as onshore wind and large PV is decreasing
- 130 euro/MWh in 2015
- 149 euro/MWh in 2030



Results

- If all large biomass plants are operational

Parameters	Standard scenarios		
	Compensated by less onshore	Compensated by less solar PV	Alternative scenario (initial)
Total investment (M€)	- 40492	- 37 415	- 43 850
Investments less required with more large biomass (M€)	= (-40492+43850)= 3358	= (-37415+43850)= 6435	
Total subsidies (M€)	13930	14 010	12 158
Additional required subsidies with more large biomass (M€)	= (13930-12158)= 1772	= (14010-12158)= 1852	



Replacing solar PV and onshore wind by large biomass leads to a significantly higher level of subsidies

Results

- If all large biomass plants are operational

Parameters	Standard scenarios				Alternative scenario (initial)
	Large biomass all plants operational compensated by less onshore (50%) and offshore (50%)	Large biomass all plants operational compensated by less onshore (50%) and PV solar (50%)	Large biomass all plants operational compensated by less offshore (50%) and PV solar (50%)	Large biomass all plants operational compensated by less onshore (33,3%), offshore (33,3%) and PV solar (33,3%)	
Total investment (M€)	- 36508	- 38 941	- 34902	- 38 924	- 43 850
Investments less required with more large scale biomass (M€)	$=(-36508+43850)=\mathbf{7342}$	$=(-38941+43850)=\mathbf{4909}$	$=(-34902+43850)=\mathbf{8948}$	$(-38924+43850)=\mathbf{4926}$	
Total subsidies (M€)	11475	13981	11489	13 242	12 158
Additional required subsidies with more large biomass (M€)	$= (11475-12158)=\mathbf{-683}$	$= (13981-12158)=\mathbf{1823}$	$= (11489-12158)=\mathbf{-669}$	$= (13242-12158)=\mathbf{1084}$	



Replacing solar PV and onshore wind by large biomass leads to a significantly higher level of subsidies

Need for sensitivity analysis

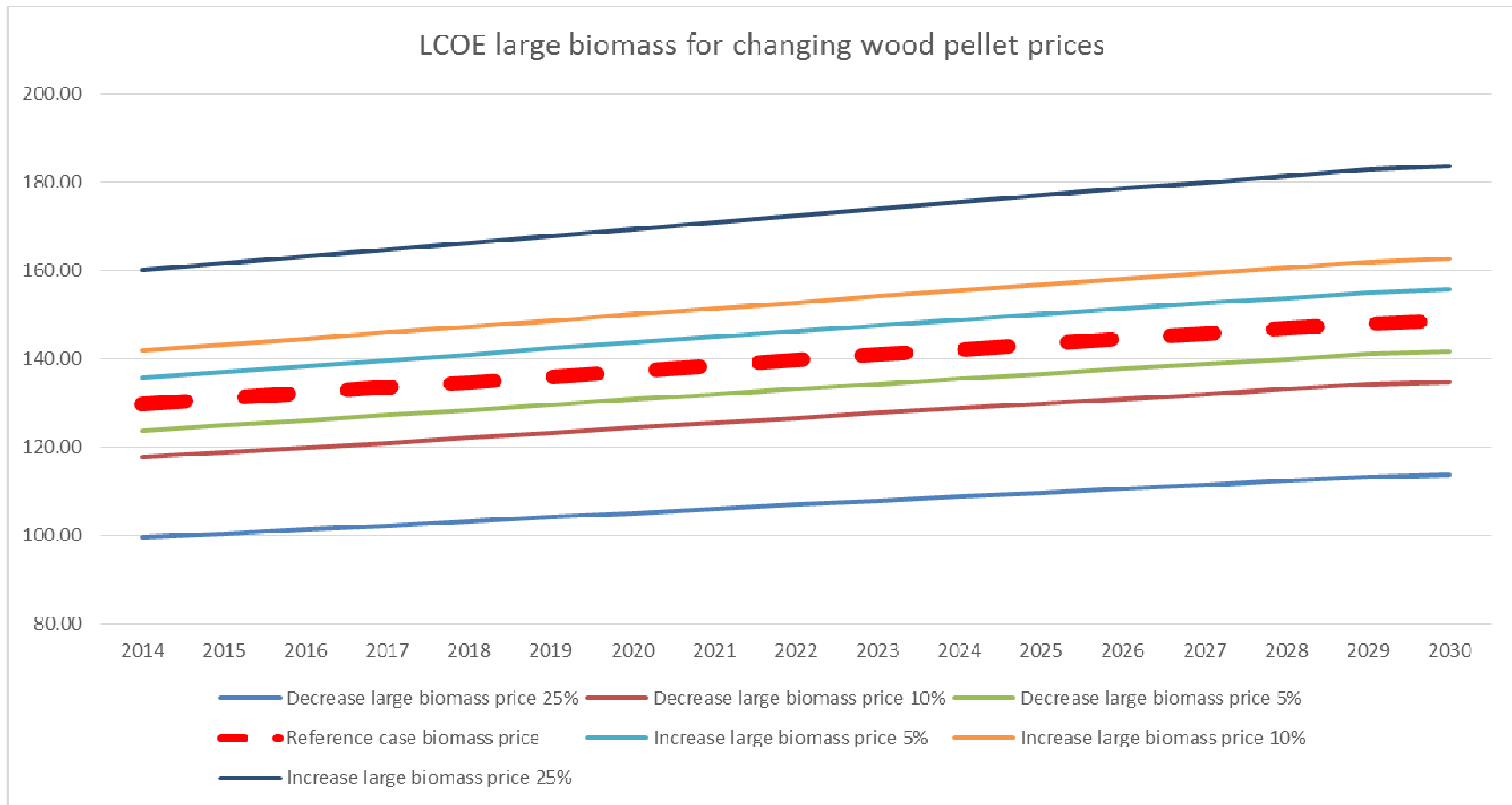
- Market evolutions are highly uncertain



Need for sensitivity analysis

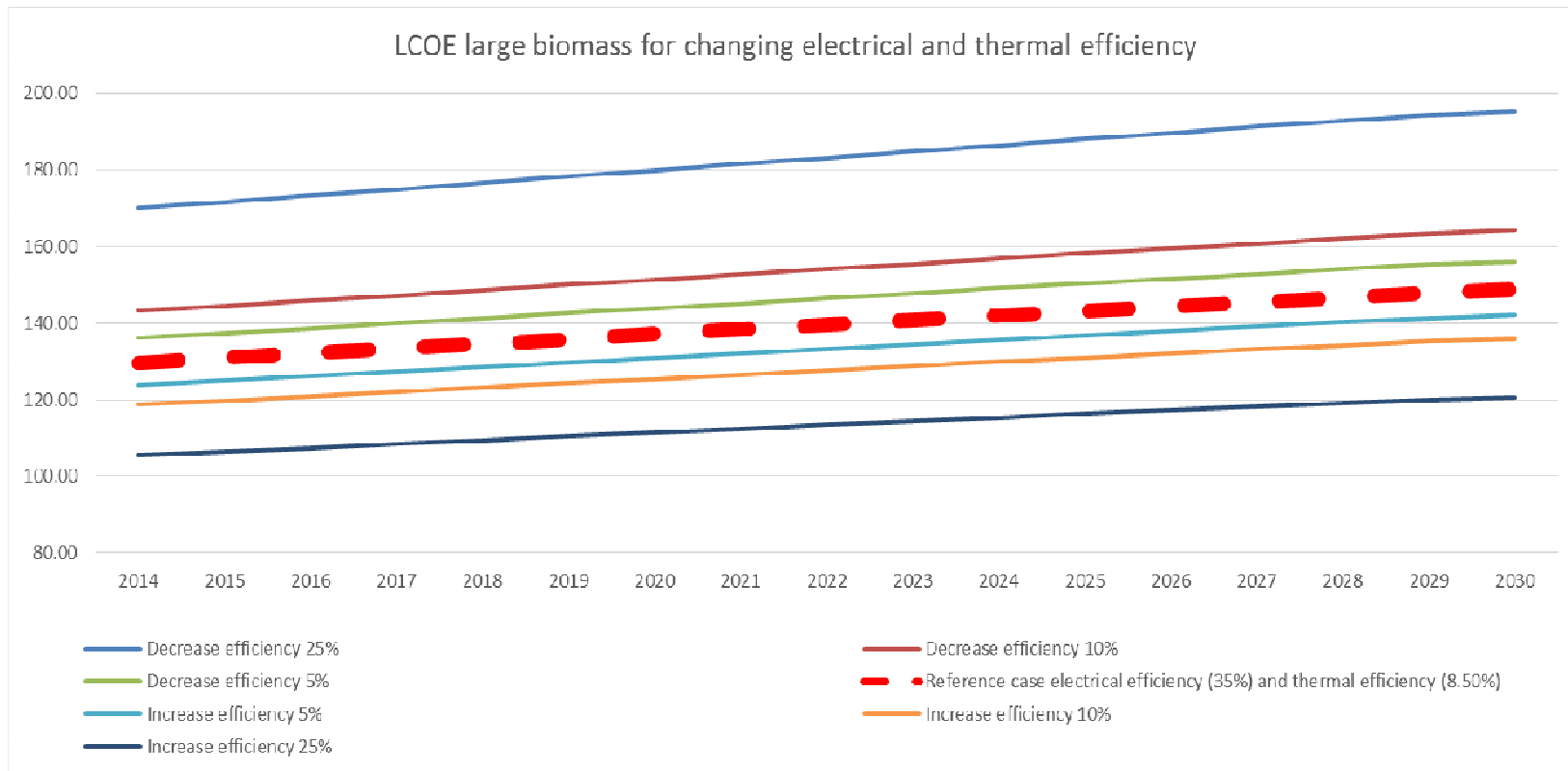
- Sensitivity analysis for the following parameters
 - Wood pellet prices
 - Electrical and thermal efficiency
 - Weighted Average Cost of Capital (WACC)
 - Exchange rate USD/EUR
- For each parameter, we will examine the impact of the LCOE and the required subsidies of
 - Decreases of the parameter by 5%, 10% and 25%
 - Increases of the parameter by 5%, 10% and 25%
- We will conduct sensitivity analysis for the case of all plants operational compensated by less onshore wind: observations for other scenarios (compensated by less offshore wind and PV solar) will be the same

Sensitivity analysis for wood pellet prices



Increase/decrease of wood pellet prices of 25% leads to an increase/decrease of the LCOE of 30-35 euro/MWh per year

Sensitivity analysis for plant efficiency

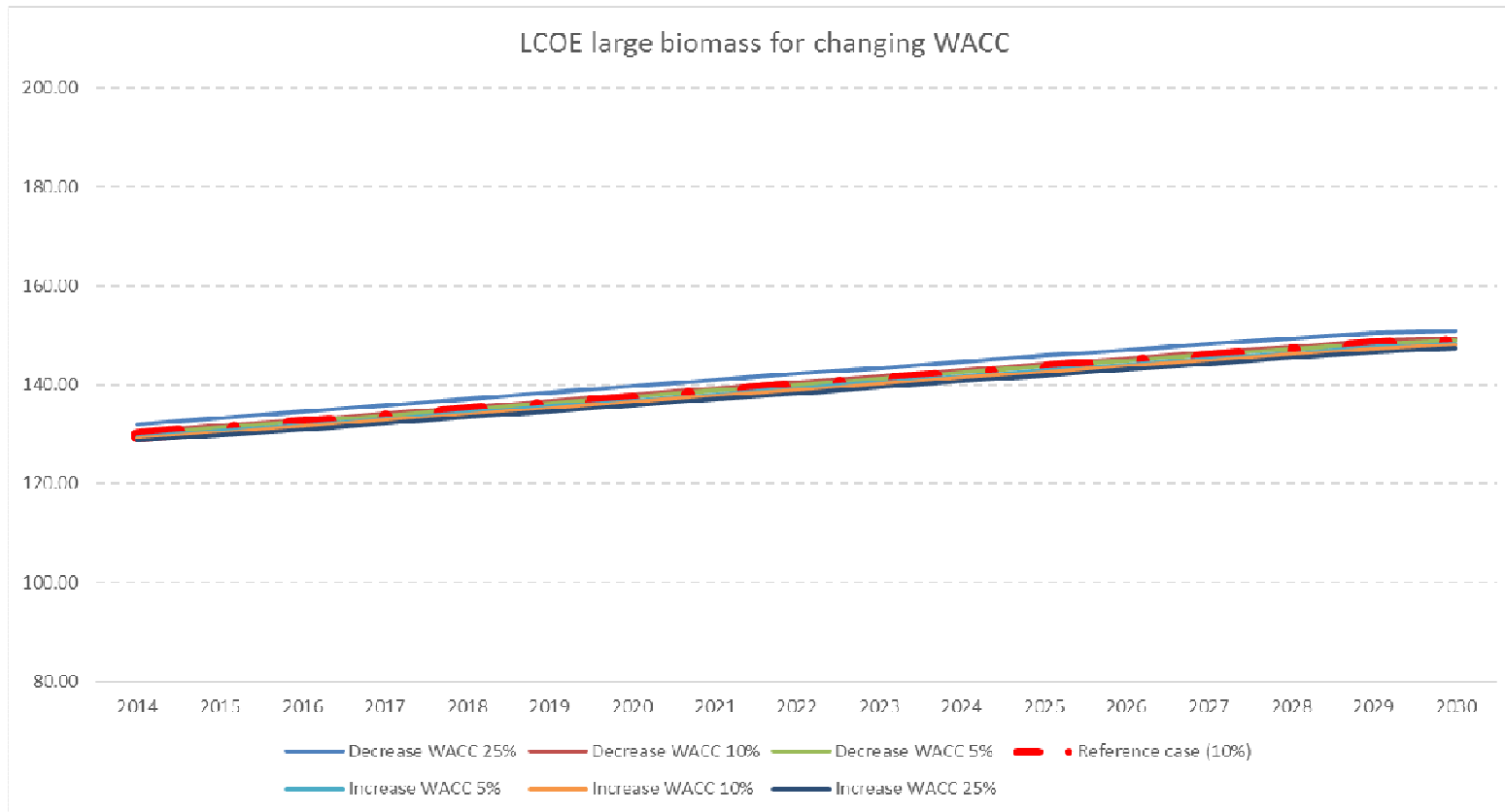


Decreases in efficiency have a higher impact on the LCOE than increases

Decrease in efficiency of 25% leads to an increase of the LCOE of 40-50 euro/Mwh

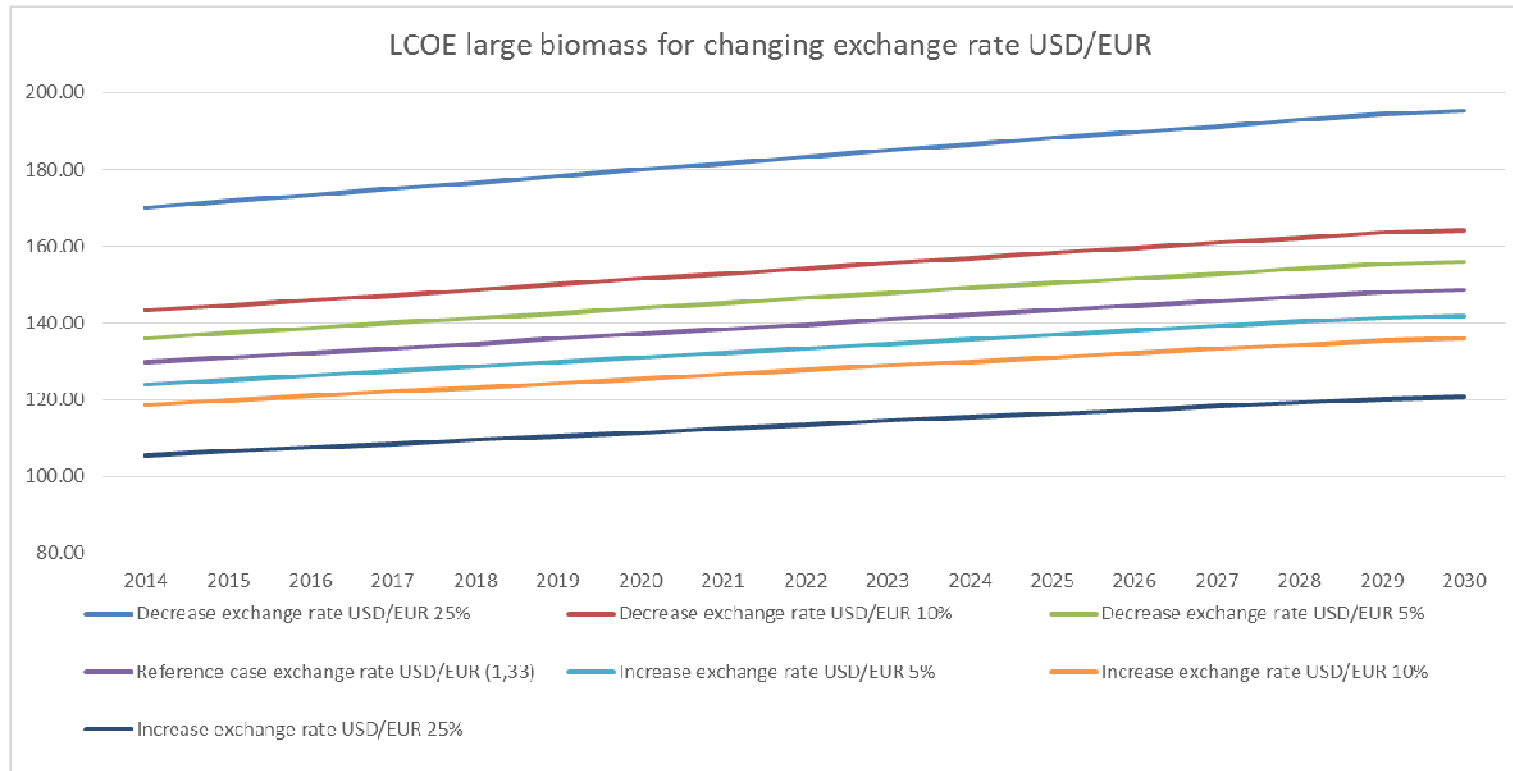
Increase in efficiency of 25% leads to a decrease of the LCOE of 20-30 euro/MWh

Sensitivity analysis for the discount rate (WACC)



Decrease/increase in the WACC of 25% leads to a change in the WACC of less than 5 euro/MWh

Sensitivity analysis for the exchange rate USD/EUR

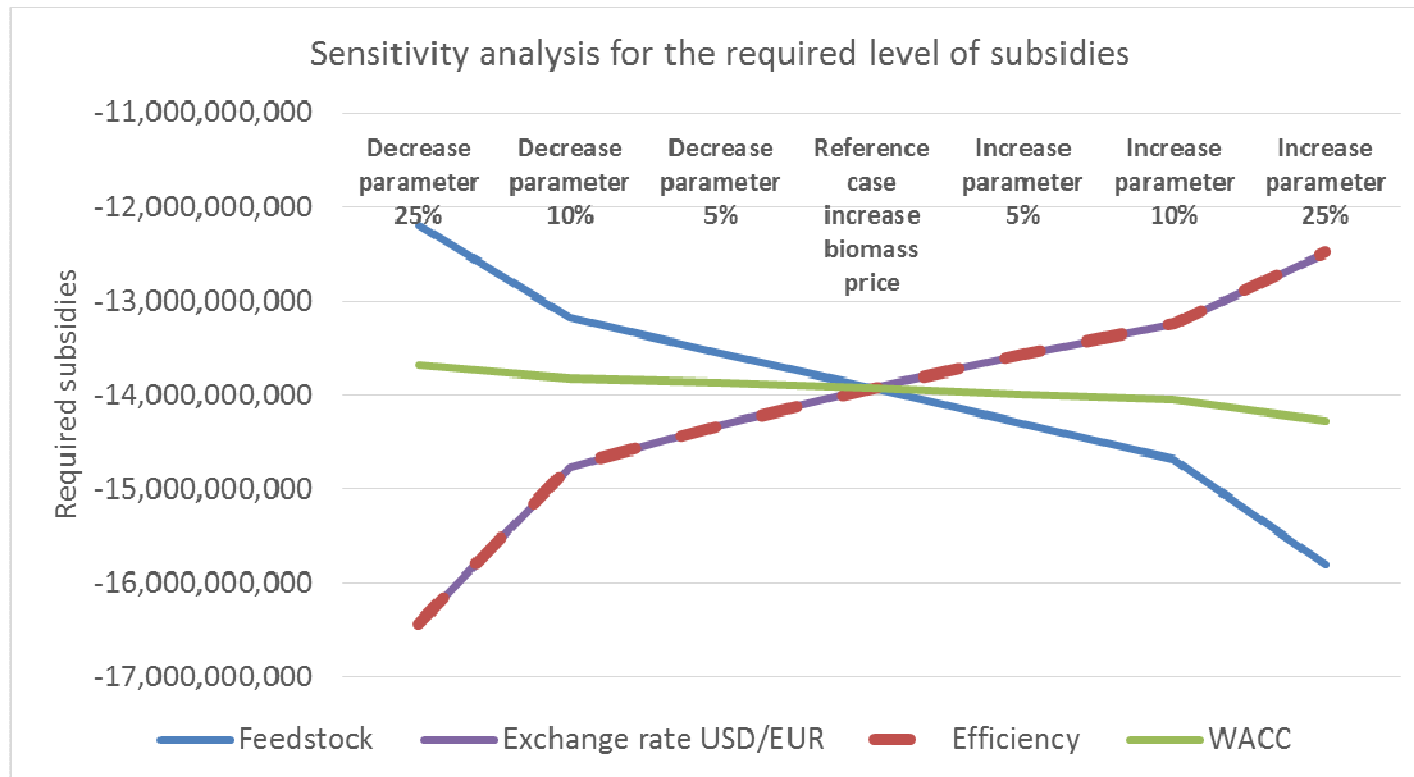


Decrease in exchange rate USD/EUR has a higher impact on the LCOE than increase

Decrease in exchange rate USD/EUR of 25% leads to an increase of the LCOE of 40-50 euro/Mwh

Increase in exchange rate USD/EUR of 25% leads to a decrease of the LCOE of 20-30 euro/MWh

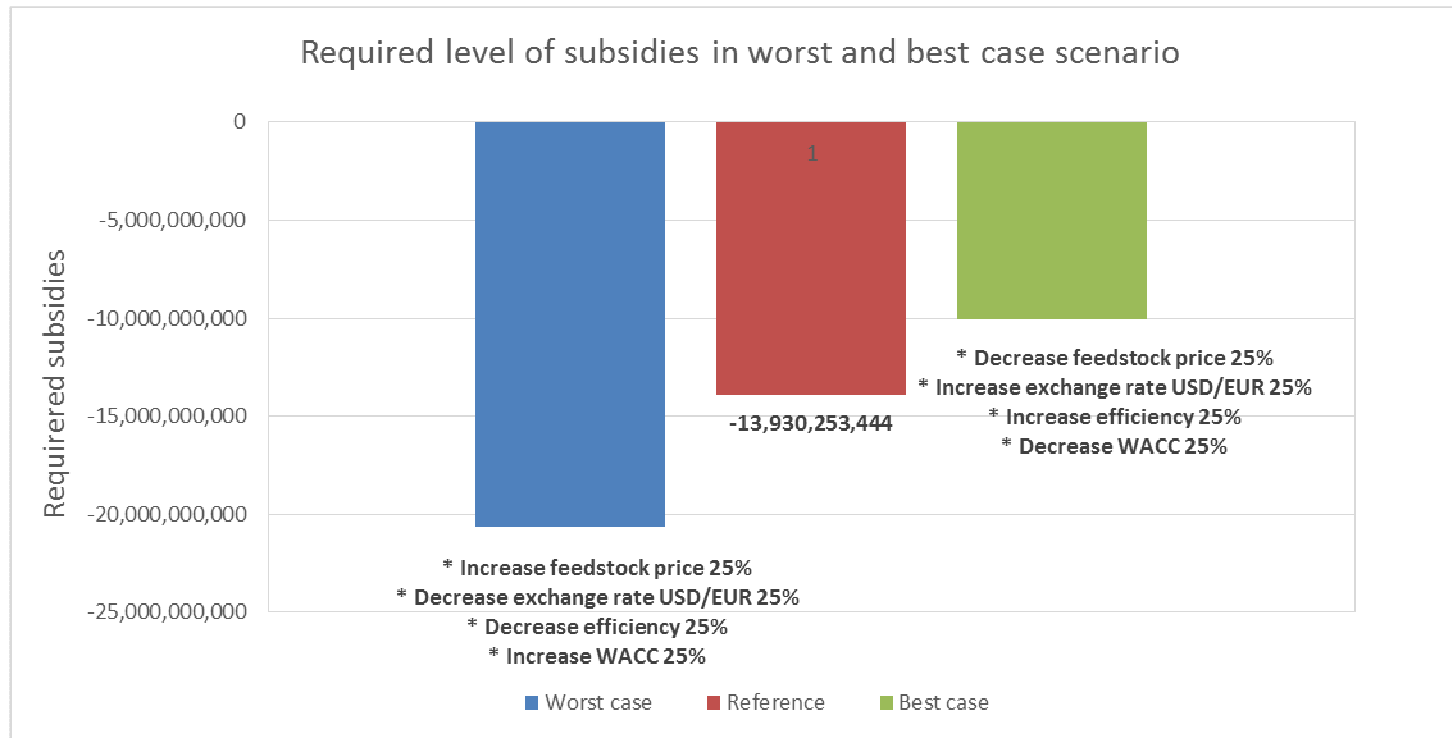
Sensitivity analysis all parameters



Decreases/increases of wood pellet prices, plant efficiency and the exchange rate USD/EUR of around 25% will lead to a difference of approximately 2 billion euros in the required level of subsidies

Decreases/increases in the WACC of approximately 25% will lead to a difference of approximately 300 million euros of required subsidies

Cumulative effect of the best case and worst case scenario for all parameters (all technologies)



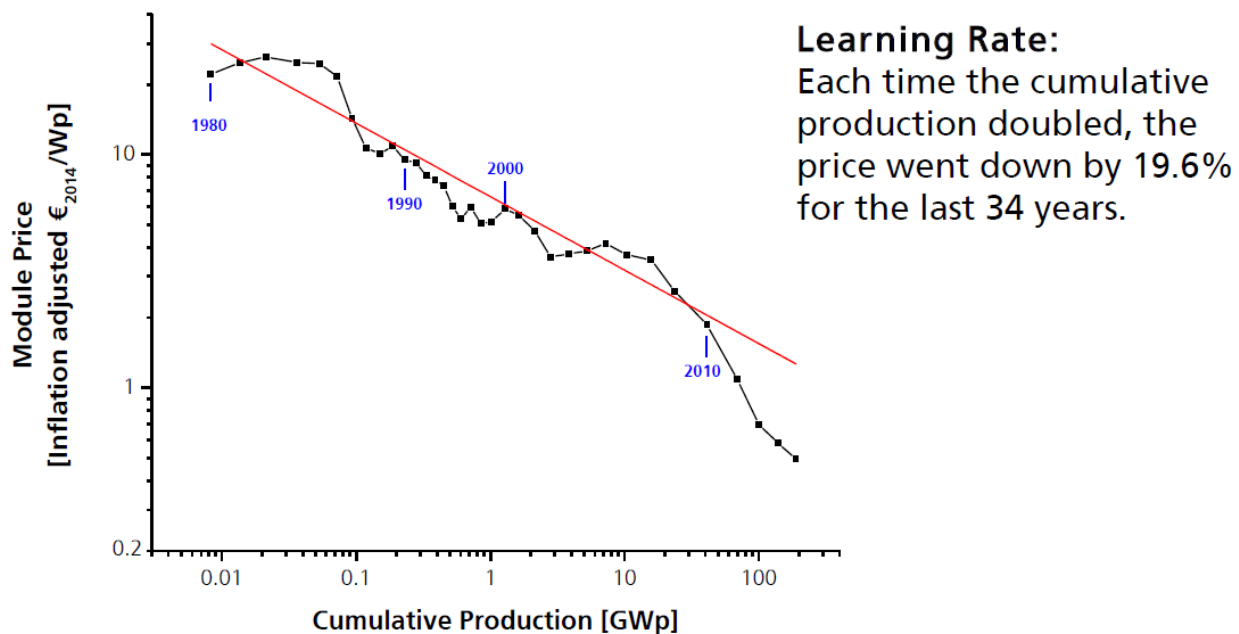
Impact on the required level of subsidies a lot higher for worst case scenario than for best case scenario:

- **Worst case scenario: approx 7 billion euros of subsidies more required**
- **Best case scenario: approx 4 billion euros of subsidies less required**

Conclusions

- The analysis demonstrates that replacing onshore wind and solar PV by large biomass will lead to a significantly higher level of required subsidies compared to the alternative scenario of the initial study
 - Large biomass has a higher LCOE than large PV and onshore wind in 2014
 - Learning effects are expected for wind and solar technologies (decreasing LCOE) while large biomass is less CAPEX-driven and OPEX and LCOE expected to increase

Evolution Solar module prices



Conclusions

- Import of wood pellets has a significant negative impact on trade balance
 - Approximately 750 million euro per year for period 2017-2030 when all plants are operational
- Required level of subsidies highly depends on parameters used for calculations
 - Exchange rate USD/EUR,
 - Plant efficiency (both electrical and thermal) and
 - Type of feedstock and related prices

Conclusions

- Life cycle assessment and uncertainty analysis of wood pellet-to-electricity supply chains from forest residues in 2015 highlights that
 - There are significant emission uncertainties related to different supply chain stages
 - The use of biomass (considering drying, storage, losses and price changes) can result in GHG reductions of 83% compared to coal-fired electricity generation

However

- When sensitivity analysis was included, the bioenergy emission profiles showed strong variation with up to 73% higher GHG emissions compared to coal

Conclusions

- Greenhouse gas implications of burning forest biomass for energy vary depending on
 - The characteristics of the bioenergy combustion technology
 - The fossil fuel technology it replaces
 - The biophysical and forest management characteristics of the forests from which the biomass is harvested



Forest biomass generally emits more greenhouse gases than fossil fuels per unit of energy produced. These excess emissions are defined as the biomass carbon debt.



- This debt is **never paid off** in the case of increased harvests
- **Re-growth** of the harvested forest removes the carbon from the atmosphere but varies strongly
- Significantly **more greenhouse gas benefits for oil/CHP than for natural gas electric capacity**

Fossil Fuel Technology	Carbon Debt Payoff (yr)
Oil (#6), Thermal/CHP	5
Coal, Electric	21
Gas, Thermal	24
Gas, Electric	>90

*

* Mamomet

Annexes

Approach to compensate for large scale biomass

- Compensate 100% with large biomass with onshore wind, offshore wind or solar PV:
 - Step 1: Copy the installed capacity from the alternative scenario from the initial study for period 2010-2016 since large biomass will only have an impact from 2017
 - Step 2: Calculate the number of GWh electricity produced by the selected large biomass scenario for the period 2017 (first year large biomass operational)-2050
 - Step 3: In the initial study, there was a scenario without capacity increases for each of the 3 technologies (scenario “no growth”). In this case, no volumes are produced by the technology over the period 2017-2050 and the installed capacity over 2017-2050 should thus be the installed capacity of this scenario in 2014 and 2017. In the initial study, there was also an alternative scenario for each of the 3 technologies. In this case, volumes produced by onshore wind, offshore wind and solar PV significantly increase over the period 2017-2050. The difference between the GWh produced in the “no growth” scenario and the alternative scenario is the number of GWh that comes on the market for each of the 3 technologies over 2017-2050 in the initial study.

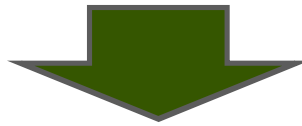
Approach to compensate for large scale biomass

- Compensate 100% with large biomass with onshore wind, offshore wind or solar PV:
 - Step 4: Calculate the difference between the GWh that comes on the market in the initial study for each of the technologies (step 3) and the GWh that comes on the market in the selected large biomass scenario. This difference is the GWh that will come on the market for each of the technologies for the new scenarios with biomass.
 - Step 5: The GWh that comes on the market in the new scenarios for 2017-2050 should now be translated in installed capacities. We use the following approach:
 - Take the installed capacity from the “no growth” scenario as the starting point
 - Divide the total GWh that comes on the market from step 4 by the number of years in the period 2017-2050: 34 years
 - Divide the result by the number of load hours per year as defined in the initial alternative scenario (load hours from the alternative scenario).
 - Add the result to the installed capacity from the “no growth” scenario. This is the average installed capacity over the period 2017-2050 in order to produce the same GWh of electricity as in the initial study.

This result is calculated in the column AU in the sheet “CapacityScenarios” of the EnergyBalanceModel

Approach to compensate for large scale biomass

- Compensate 100% with large biomass with onshore wind, offshore wind or solar PV:
 - Step 6: Use a growth factor so that the installed capacity increases year by year.
 - Step 7: Check that the sum of the installed capacities equals 34 times the results from column AU



Lines in green in the sheet “CapacityScenarios” of the EnergyBalanceModel

Approach to compensate for large scale biomass

- Compensating with combinations of onshore wind, offshore wind and solar PV
 - 2 options
 - 50% of 2 selected technologies
 - 33,3% of all 3 technologies (onshore wind, offshore wind and solar PV)
 - Only for biomass scenario all plants operational
 - Same approach as for 100% compensation by one technology but 50% or 33,3% of the production volumes by large biomass are taken to carry out the calculations.

Example calculation for onshore wind all large biomass plants operational (EnergyBalanceModel)

1. Total number of GWh produced by large scale biomass: **230,04 TWh** (cell C11 in sheet “Total production”)
2. *GWh electricity production for scenario “no growth” for onshore wind: **82,130 TWh** (cell C20 in sheet “Total production”), *GWh electricity production for the alternative scenario for onshore wind: **669,649 TWh** (cell C19 in sheet “Total production”), * Difference in GWh=**587,5 TWh**
3. Difference in GWh between the first 2 steps: **357,5 TWh**
4. **$357,5/TWh/34/2200= 4779 MW$**
5. *Installed capacity per year for the lowest scenario for onshore wind: 1098 MW, * $4779+1098= 5877 MW$ (cell AU93 in the sheet “CapacityScenarios”), *5877 is the average installed capacity per year in order to produce the same GWh as in the initial study taking into account the new large biomass plants
6. Use a growth factor so that the installed capacity per year grows every year and check if the sum of all capacities for years 2017-2050 still equals 34 times the average installed capacity in AU93, * $34*5877=199,8 GW$, $SUM(M93:AT93)= 199,8 GW$

Thank you

Antoon Soete

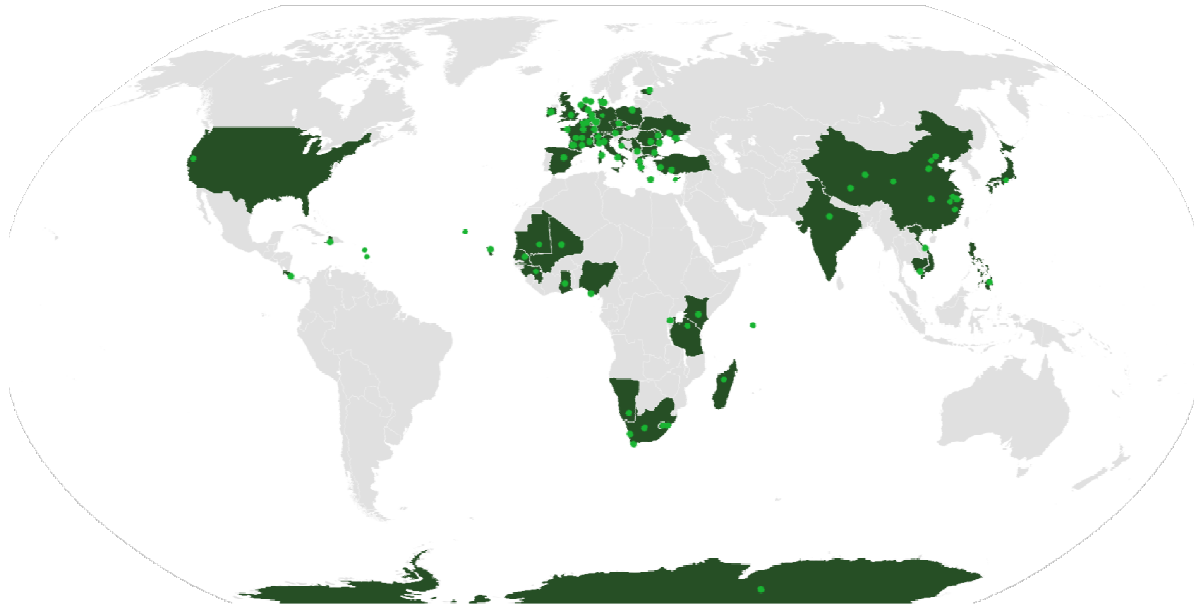
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