Rentizelas, Athanasios and Li, Jun (2016) Co-firing torrefied biomass for power generation : assessing the trade-offs of downstream torrefaction from a whole system's perspective. In: 24th European Biomass Conference and Exhibition, 2016-06-06 - 2016-06-09. ,

3DV.2.19

Co-firing torrefied biomass for power generation: Assessing the trade-offs of downstream torrefaction from a whole system's perspective

Dr. Athanasios Rentizelas[1], Dr. Jun Li[2]

[1] athanasios.rentizelas@strath.ac.uk [2] jun.li@strath.ac.uk

University of Strathclyde Engineering

Background

Biomass is one of the main renewable energy sources that can assist in delivering the ambitious renewable energy targets of European and other countries. One of the challenges in increasing biomass use is the complexity and cost of the logistics and the supply chain design and management, especially when long-distance international biomass transportation is required. In the UK, indigenous biomass resources are limited and biomass imports are continuously increasing. Torrefaction of biomass has received a lot of attention lately due to the potential logistical advantages on long-distance biomass supply, such as increased transportation efficiency, hydrophobicity and improved behavior during storage. Traditionally, torrefaction is performed upstream in the supply chain, before the shipping stage.

Aim

The aim of this work is to assess the feasibility of downstream biomass torrefaction (at the co-firing plant) for long-distance international biomass supply chains.

Several co-firing rates are examined, to identify the effect of potential economies of scale in the long-distance supply chain, the required investment and resulting system performance change at the co-firing unit (de-rating). A whole system approach is taken, meaning that both the biomass supply chain and the co-firing unit performance are considered to have a better understanding of the potential benefits or drawbacks at the whole system level. The analysis includes techno-economical and environmental performance aspects and focuses on a case study application of a UK co-firing station procuring Palm Kernel Shell (PKS) biomass from South Asia (Indonesia).

Upstream vs downstream torrefaction

Advantages of upstream torrefaction

- Efficient shipping & other transportation due to increased material and energy density of torrefied biomass when pelleted (black pellets)
- Reduction of material degradation during storage/transportation
- Feedstock properties very similar to coal (minimal changes to co-firing plant boiler & auxiliary equipment)

Disadvantages of upstream torrefaction

- Energy intensive process – usually consumes significant part of the biomass feedstock or requires additional input of high value/ fossil energy sources
- Requires pelleting of torrefied feedstock and then grinding of pellets at the end-use location (additional processing adds cost and energy consumption)

Advantages of downstream torrefaction

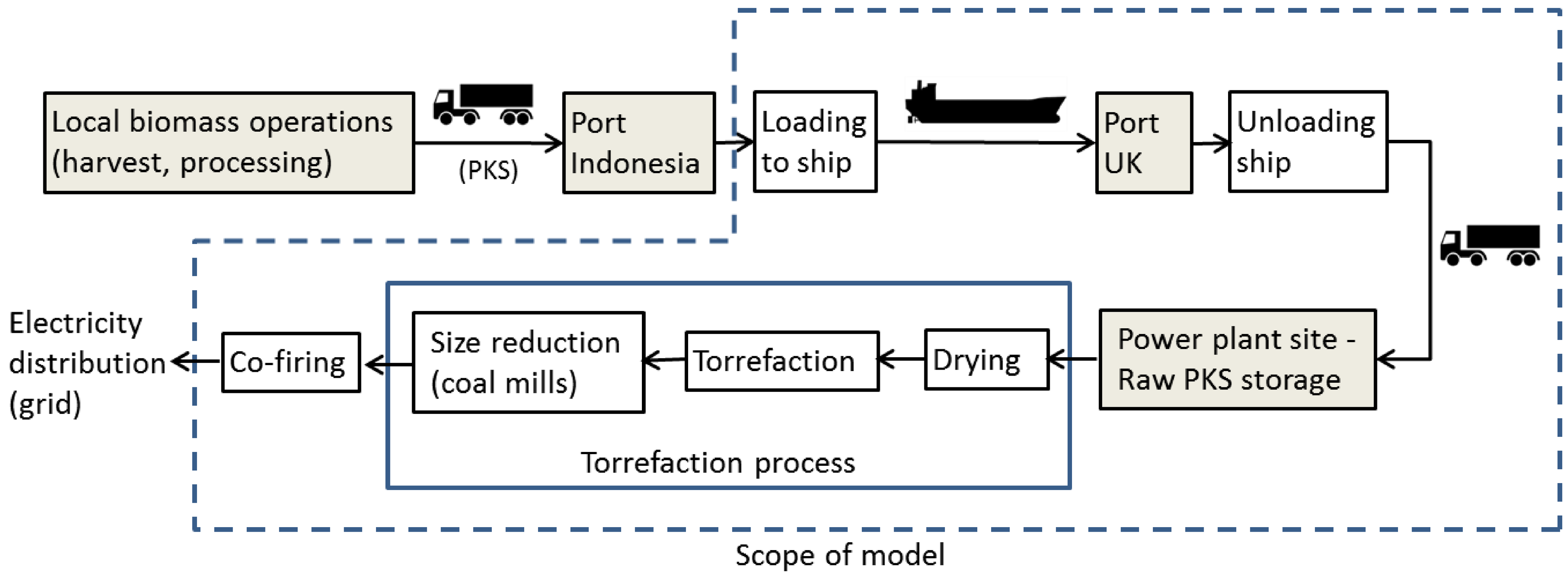
- Pelleting and grinding stages are avoided (less investment cost, energy input, supply chain complexity)
- Waste energy from co-firing plant can be used to perform torrefaction (more feedstock ultimately available for energy conversion; reduced overall system CO2 emissions)
- Feedstock properties very similar to coal (minimal changes to co-firing plant boiler & auxiliary equipment)

Disadvantages of downstream torrefaction

- Reduced efficiency of international transportation stage (shipping)
- Not suitable for all feedstock types – need to be relatively low moisture & high density

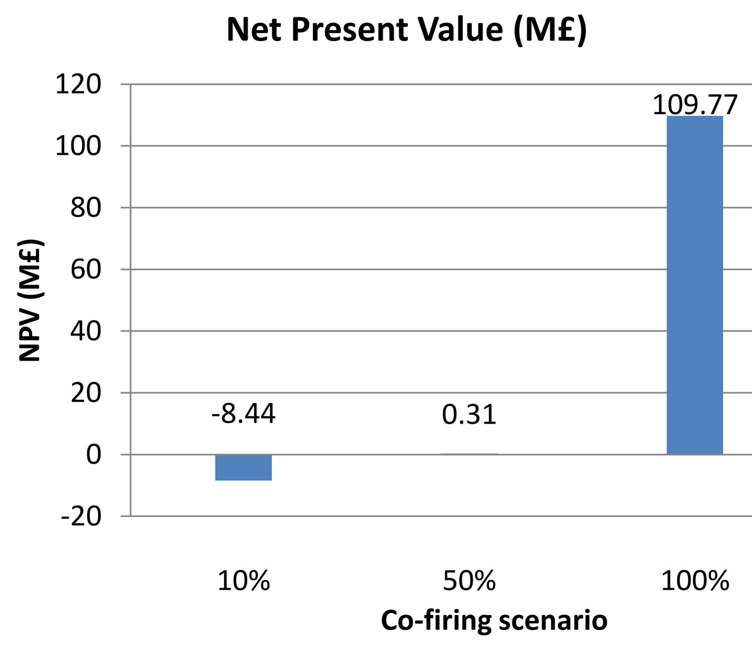
Main Conclusions

- Only 100% biomass is profitable for the UK case; 50% co-firing is marginally profitable
- Biomass purchasing cost is the most significant cost factor
- High biomass co-firing ratios lead to increased power plant de-rating
- De-rating is the main source of increased emissions in the feedstock supply chain
- Higher ROC payments for higher co-firing ratios outweigh by far the lower system-wide efficiency
- Profitability very sensitive to coal, feedstock and ROCs prices
- Sea transport and biomass density the most critical supply system-related factors
- No single factor change by 25% can render the 100% biomass scenario unprofitable



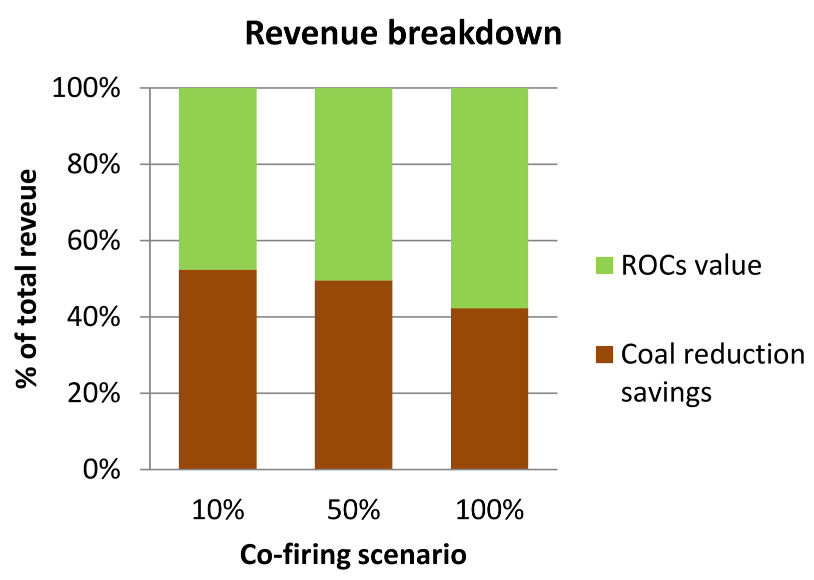
RESULTS

Investment, Technical & Environmental Analysis (200 MW_e)

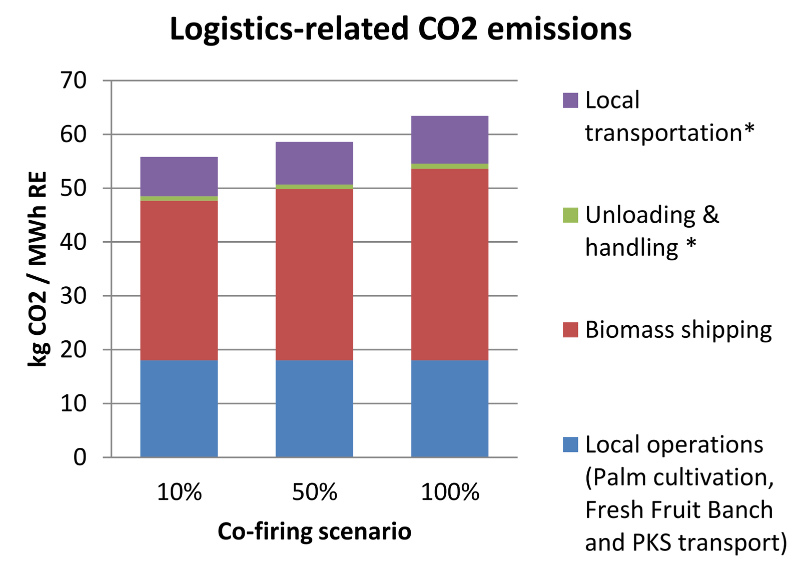


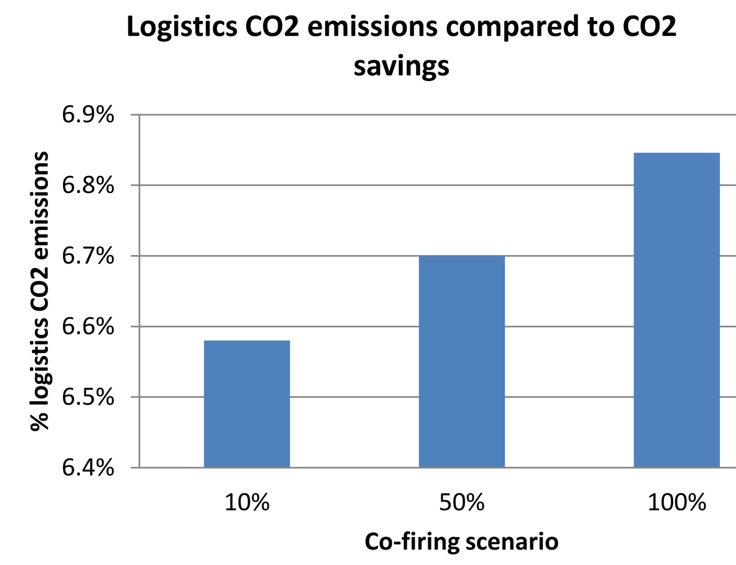
Expenditure breakdown % of total (PV)			
Expense type	Scenario 1 10% co-firing	Scenario 2 50% co-firing	Scenario 3 100% biomass
Torrefaction Unit Investment	15.2%	10.2%	8.4%
Storage space for raw biomass Investment	1.3%	0.3%	0.2%
Biomass purchasing FOB	42.8%	46.7%	47.3%
Long distance transportation (shipping)	18.9%	20.6%	20.9%
Unloading & handling*	2.1%	2.3%	2.4%
Local transportation*	1.9%	2.1%	2.1%
Reduction in electricity output	12.2%	14.7%	16.5%
Personnel for torrefaction plant	2.9%	1.3%	0.8%
O&M	2.6%	1.7%	1.4%

* Additional feedstock amount only (compared to coal only scenario)



Co-firing plant technical calculations				
Cofiring Scenario	Baseline: Coal	Scenario 1 10% co-firing	Scenario 2 50% co-firing	Scenario 3 100% biomass
Coal feed rate (t/h)	79.24	71.32	39.60	0.00
Biomass torrefied feed rate (t/h)	0	8.26	41.33	82.66
Annual coal used (t/a)	602194	542002	300960	0
Annual Biomass raw used (t/a)	0	84816	424627	849254
Electrical efficiency of Plant (%)	38.74%	38.18%	35.64%	31.85%
Electricity generated (GWh/a)	1510	1488	1389	1241





Sensitivity Analysis