Imperial Network of Excellence in Sustainability through Life Cycle Approaches
‘Imperial Life Cycle Network’

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@ICL_LifeCycle
Group: ‘Life Cycle Community UK’
Life Cycle Assessment, counterfactuals and policy making
Carly Whittaker
Welcome!

Proud to kick-start the LCA Network Seminar Series
A little bit about me

- Studied at Imperial College (Biology BSc, Forestry MSc)
- Worked in Life Sciences Department in 2006

- First job examined bioenergy supply chains in the UK- using biomass for heat, power and biofuels.
- Used life cycled assessment to examine the potential that biomass had to mitigate GHG emissions
Life cycle assessment for life…
Overview of today’s seminar

- Intro to the UK Policy Challenge: Reducing GHG emissions from transport
- The Renewable Transport Fuel Obligation
- How we use LCA
- Attributional LCA – regulation
- Consequential LCA – policy development
- Case study: Fuels produced from waste plastics.
UK Policy Challenge: Reducing GHG emissions from Transport
UK Policy challenge: Reducing emissions from transport

UK is committed to the Net Zero by 2050 - legally binding target

Policy challenge is
Reducing GHG emissions
(Reducing energy demand)

UK GHG emissions trajectory to 2050

Emissions from UK transport
Transport emissions not falling

BEIS (2019) Final UK GHG emissions national statistics
The Renewable Transport Fuel Obligation
Renewable Transport Fuel Obligation (RTFO)

- Has been operating since 2008. On average saves 2.5 Mt CO$_2$/year, and is increasing!
- Is one of the Government's main policies for reducing GHG emissions from fuel supplied for use in transport
- Rewards production of renewable transport fuels of biological and non-biological origin
- Typical feedstocks include…

*Used cooking oil*  
*Wheat*  
*Food waste*
RTFO Order – Fuel suppliers to UK must provide a **volume** of sustainable renewable fuel, based on their overall volume of fuel they supply to road transport.

This is met by tradable Renewable Transport Fuel Certificates (**RTFCs**) that are awarded per litre/kg of renewable fuel.

Suppliers can get RTFCs by:
- Producing renewable transport fuels
- Buying renewable transport fuel and getting RTFCs
- Or paying the 'buy-out' price for RTFC certificates
Two obligations

Main RTFO: “Conventional” renewable fuels

Development fuel: Advanced renewable fuels

Policy mechanisms

RTFO obligation and development fuels sub target
The RTFO Unit publishes a list of accepted and qualifying feedstocks for RTFCs, and defines:

- Fuels made from products
  - E.g. crops, industrial products

- Fuels made from qualifying wastes and residues
  - E.g. food waste, used cooking oil, agricultural residues

- Fuels made from energy crops
  - E.g. willow, Miscanthus, switchgrass

![Chart showing biofuel distribution with 66% and 34% categories]
Saving GHG emissions from transport

- Renewable fuels must meet **50%** or **60%** GHG emission saving threshold
- Compared to a ‘fossil fuel comparator’
- Regulate this via LCA methodology – attributional LCA
- 2018 saved approx. 4 Mt CO₂
- Equivalent to taking 1.8 million cars off the road

*RTFO Annual Report 2018*
How we use LCA
What is your Question?

What are the environmental impacts of producing 1 litre of bioethanol from wheat?

Spot the difference

What are the environmental impacts of producing bioethanol from wheat?

**Attributional LCA**
- Looks at a single unit of production
- Provides a snap shot of impacts
- Relevant to person causing emissions

**Consequential LCA**
- Looks at changes in production
- Provides a ‘great picture’ of impacts
- Considers ‘knock on’ effects

**Regulation**

**Policy Analysis**

The LCA studies will be done in a different way
Provides a snapshot of impacts and provides “one answer”

**In the RTFO:** GHG Methodology to calculate “carbon intensity” (g CO$_2$ eq. per MJ fuel) to test whether a renewable fuel meets the minimum GHG emission saving.

\[ E = e_{ec} + e_l + e_p + e_{td} + e_u - e_{sca} - e_{ccs} - e_{ccr} - e_{ee} \]

The RTFO: How we regulate it?

- RTFO Unit based in Hastings

- Get around 1,000-2,000 consignments of fuel per month, covering ~300-400 million litres of fuel

- Suppliers must meet GHG emission saving of 50% or 60%

- They must provide carbon intensity figure (CI) for their fuel

- Also need to declare if there are any land use changes that have occurred

- All applications must be verified by third party independent verifier

- 98% of fuel is audited by a Voluntary Scheme, who calculates the CI
RED GHG Accounting Methodology: Equation

\[ E = e_{ec} + e_{l} + e_{p} + e_{td} + e_{u} - e_{sca} - e_{ccs} - e_{ccr} - e_{ee} \]
\[ E = e_{ec} + e_I + e_p + e_{td} + e_u - e_{sca} - e_{ccs} - e_{ccr} - e_{ee} \]

- \( E_{ec} \): Emissions from extraction or cultivation of raw materials
- \( E_I \): Annualised emissions from carbon stock changes caused by land-use change
- \( E_p \): Emissions from processing
- \( E_{td} \): Emissions from transport and distribution
- \( E_u \): Emissions from fuel in use (equal zero)
- \( E_{sca} \): Emission saving from soil carbon accumulation via improved agricultural management
- \( E_{ccs/ccr} \): Emission saving from carbon capture
- \( E_{ee} \): Emission saving from excess electricity from cogeneration
We usually only see these ones used/reported.
Consequential LCA: Policy Analysis

- Looks at consequences of changes in production on overall GHG emissions

- E.g. Indirect land use effects
  - Considers the GHG impacts of indirect land use change due to increased demands for crops for renewable fuel production.

- Avoiding GHG emissions that occur due to waste disposal

- These are usually impacts that are directly out of the control of the supplier, but we want to encourage suppliers to choose outcomes that lead to GHG emission savings – and tailor policies accordingly
Following RED, REDII was finalised in December 2018 and introduces “recycled carbon fuels” that can contribute to the share of renewable energy in the transport sector.

Recycled carbon fuels are transport fuels made from fossil derived wastes that are not suitable for reuse or recycling, or cannot be avoided.

Therefore, there has since been increasing interest in ‘recycled carbon fuels’ by fuel developers and we have been considering if they can deliver GHG emission savings.

REDII is yet to set out a methodology to calculate GHG emission saving thresholds from recycled carbon fuels so we are proposing to develop our own GHG methodology.
Fuels made from waste plastic?

- The Government currently incentives the use of biomass waste for fuel production.

- But a good proportion of this is heavily mixed with plastic-difficult to separate and must be disposed of together.

- E.g. contaminated food packaging, polycotton textiles, sanitary waste.

- We recognise that RCFs are not renewable but have explored the potential GHG emission savings that can be achieved by RCFs.
How is this waste currently disposed of?

Black bag waste and residual wastes ~ 23-30 MT – **not recyclable material**

**Landfill is the most common end-of-life fate (~50%)**

Followed by incineration for electricity (~30%) and for electricity and heat (~20%).
How to frame the LCA?

- Compared the GHG emissions from changing how fossil wastes are currently disposed

![Diagram showing the current and RCF situations for fossil waste and aviation fuel](image)

\[X = \text{avoided GHG emission}\]
Calculating the GHG emission savings

- Calculates GHG emissions from ….

“What would have happened”

Define wastes → Current disposal → GHG emissions from disposal → + GHG emissions from replacing electricity and heat → GHG emissions from producing RCFs → GHG emissions from burning RCFs

Emitted in counterfactual

Lost from counterfactual

In addition to counterfactual

Avoided

“What will happen”

Emitted

Avoided
The GHG emissions from disposal

- Landfill – negligible for fossil component – not for biological waste however

- Energy from waste (EfW) GHG emissions from **combusting** the waste to generate heat or power

- These emissions are avoided in the RCF scenario - but that also means there is a penalty in the RCF scenario

<table>
<thead>
<tr>
<th>Landfill</th>
<th>EfW (power)</th>
<th>EfW (CHP)</th>
<th>Export CHP</th>
<th>Gases only: Coke ovens</th>
</tr>
</thead>
<tbody>
<tr>
<td>No replacement</td>
<td>Grid average electricity (2024 projected)</td>
<td>Grid average electricity and natural gas</td>
<td>Grid average electricity in country and natural gas</td>
<td>Natural gas</td>
</tr>
</tbody>
</table>
The GHG emissions from replacing electricity and heat

➢ The heat and electricity needs to be replaced… but what with?

➢ Also need to think how this may change over time

<table>
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<tr>
<th>Landfill</th>
<th>EfW (power)</th>
<th>EfW (CHP)</th>
<th>Export CHP</th>
<th>Heat only (cement kilns)</th>
<th>Export cement kiln (EU av. Mix)</th>
<th>Gases only: Coke ovens</th>
</tr>
</thead>
<tbody>
<tr>
<td>No replacement</td>
<td>Grid average electricity</td>
<td>Grid average electricity and natural gas</td>
<td>Grid average electricity in country and natural gas</td>
<td>Cement kiln mix (coal, natural gas, biomass)</td>
<td></td>
<td>Natural gas</td>
</tr>
</tbody>
</table>

GHG Emissions from producing RCFs
- Are there any opportunities to capture carbon during the processing stages?
- Gasification technologies produce a pure CO₂ stream from the gasifier that could be captured.

Unlike biofuels, CO₂ emissions from burning RCFs are accounted for
- This is fossil CO₂
Results

**Emitted** when we make RCF
- Combustion emissions
- Processing emissions
- Energy ‘penalty’

**Avoided** when we make RCF
- Emissions from incineration

Fossil fuel comparator (94 g CO₂e/MJ)

Average result
The counterfactual affects the results

The chart shows the comparison of greenhouse gas (GHG) savings and emissions across different scenarios. The y-axis represents the GHG Saving percentage, ranging from 350% to 35% conversion efficiency.

- **Avoided Emissions**
  - Landfill
  - EfW power only (UK)
  - EfW CHP (UK)
  - EfW with CHP (export)
  - Cement kiln (UK)
  - Cement kiln (exported)

- **Emitted Emissions**
  - Fuel use emissions
  - Process emissions
  - Feedstock counterfactual emissions

- **Total GHG Savings**
  - -117%
  - 50%
  - 22%
  - -170%
  - -103%
  - -118%

35% conversion efficiency
Is landfill an appropriate comparison system for RCF feedstocks?
- UK: Targets to reduce waste to landfill
- Landfill not an option we should compare against

Does it act as a carbon store?
- There is a considerable biological component of the waste would degrade and be emitted as methane.
- Could remodel RCF study to include biogenic methane
- But we know that it’s good to divert biomass from landfill

Change of question: If material is diverted from landfill- where should it go?
If material is diverted from landfill - where should it go?

- Our research suggests RCFs are “next best” option compared to landfill
  - If the RCF plant is more efficient than an incinerator
  - If burning waste is higher GHG than the grid average electricity
  - If the feedstock is mixed with biomass - all the better.
  - Can use these criteria to build the GHG assessment methodology

- Diagram showing the waste hierarchy:
  - Prevention
  - Preparing for reuse
  - Recycling
  - Recovery
  - Disposal
  - Heat
  - RCFs
  - Electricity
Risks and tailoring the policy

- What is the risk that the policy objective will not be met?
- The policy objective is to reduce GHG emissions (from transport).
- Need to test the risks against the results of the LCA model

“Pre-Mortem” Questions to determine impact on GHG emissions
- What different types of RCF could there be?
  - do they have the same counterfactual?
  - What if we supported all RCF at the same level?
- Where do the savings occur? What happens when we import RCFs from abroad?
- How do we stop recyclable material getting in?

Test the model and find options that mitigate risk by:
- Adding specific feedstock criteria
- Not allowing double counting of savings
- Setting appropriate financial support
UK is committed to the Net Zero by 2050 challenge to find more options for mitigating GHG emissions where possible.

The RTFO mitigates on average 2.5 Mt CO$_2$ eq./year and this due to increase over time with increasing targets.

The RTFO uses (a)LCA to regulate the GHG emissions savings of renewable transport fuels- only supporting those that meet the minimum criteria.

Policy development requires a consequential LCA modelling to understand the GHG impacts of new policies.

The (c)LCA model can be tested to assess the risk of the policy not meeting the objectives, and the policy can be tailored accordingly.
What happens next?

- We’re going to be consulting on this policy later this year.
  - Will include changes on
    - E10
    - Sustainability criteria
    - Changes to how we support hydrogen
    - RCFs

- REDII and EU Exit?

- Any questions or follow up conversations contact me on carly.whittaker@dft.gov.uk

- Happy to take questions now from the LCA experts!

- Links to reports
Thank you all for your attention and participation!

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