Energy balance of SRC willow used for managing farmyard washings

– how does it compare to a conventional wastewater treatment works?

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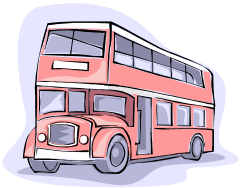
Introduction

UK target:
15% renewable energy by 2020

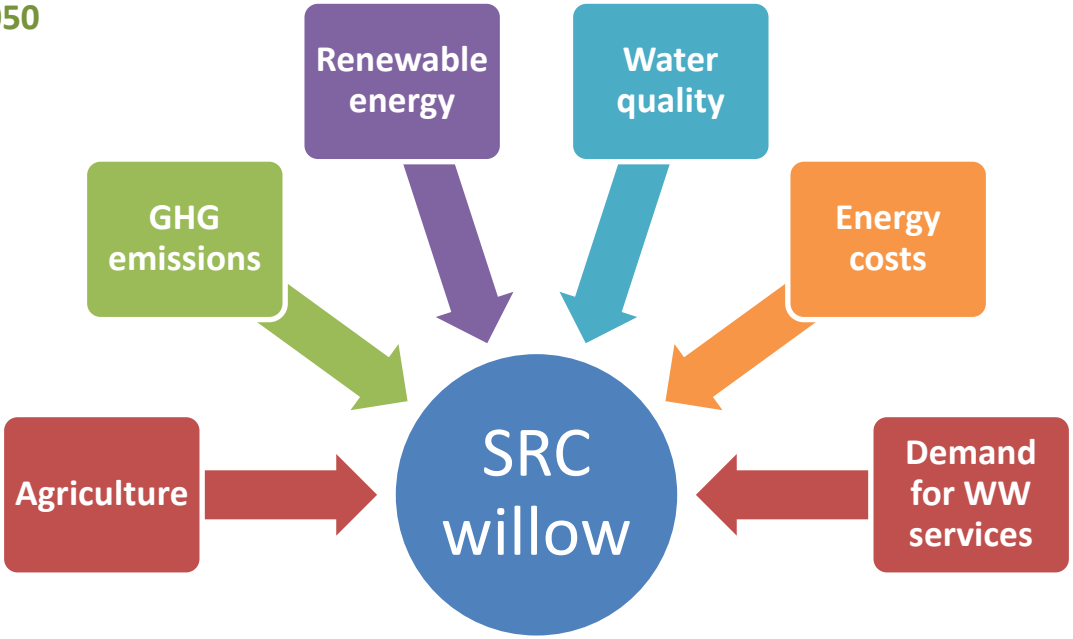
EU Directives
Urban Waste Water Treatment Directive
Habitats Directive
Water Framework Directive

UK target:
80% cut in GHGs by 2050



Water & sewerage sector GHG emissions are equivalent to emissions from all buses in the UK

Source: OFWAT (2010)



NI Water's annual energy bill £34 million

Source: NI Water (2014)

75% of N Ireland's land is used for agriculture

Source: DARDNI (2012)

'Since 1964 the population of the UK has grown by over 10 million people (18.7%). About half of this growth has occurred since 2001.'

Source: Office for National Statistics

What is SRC willow?

Short rotation coppice (SRC) willow

- Deciduous tree (*Salix*)
- Grows well in temperate climates
- Dual uses
  - Biomass for energy
  - Management of wastewater effluent

As an energy crop…

✓ Good energy balance

✓ Performs well environmentally and has been recommended over liquid biofuel crops in Irish conditions (Styles & Jones, 2007)

Overview

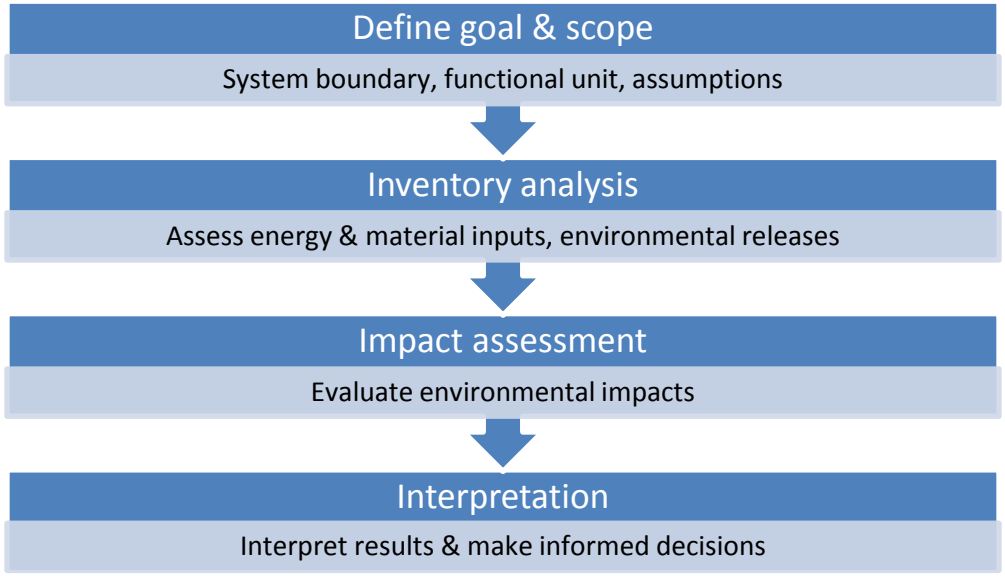
Aims

- Analyse energy balance of an SRC willow plantation to which farmyard washings are applied
- Compare energy demand with that of a conventional WWTW

Scope

- Experimental plantation AFBI, Hillsborough, N Ireland
- 4 ha site irrigated with dirty water
- Plots are surrounded by guard rows
- Established in 2008

Source: NordNordWest, Wikimedia Commons, http://en.wikipedia.org/wiki/File:Northern_Ireland_location_map.svg



Life cycle analysis

- Cradle-to-grave analogy

➢ Production of SRC willow in the field
➢ Use of the resulting wood chip for energy.

Establishment and growth

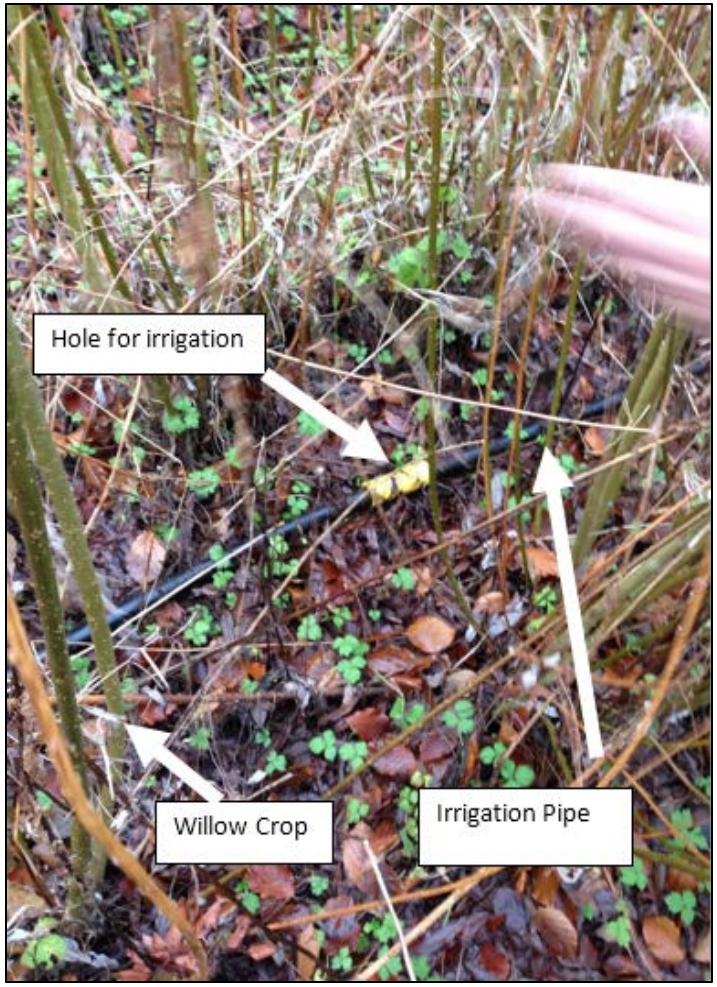
Willow being planted with the use of a step planter

Planting

Source: Caslin, B., Finnan, J. & McCracken, A. (2010) *Short Rotation Coppice Willow Best Practice Guidelines.* AFBI (Agri-Food and Biosciences Institute) & Teagasc

Growth

Irrigation and harvesting



Irrigation pipework

Willow harvesting

Class Jaguar direct chip harvester Co Wicklow (Sligo IT)

Source: Caslin, B., Finnan, J. & McCracken, A. (2010) *Short Rotation Coppice Willow Best Practice Guidelines.* AFBI (Agri-Food and Biosciences Institute) & Teagasc

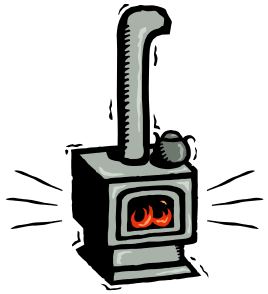
SRC willow LCA – system boundaries

Weed/pest control, ploughing, planting

Irrigation, herbicide

Harvesting, chipping, transport, drying

Heat



Establishment

Growth

Harvest

Use

Exclusions

Machinery manufacture

Indirect land use change

Building construction

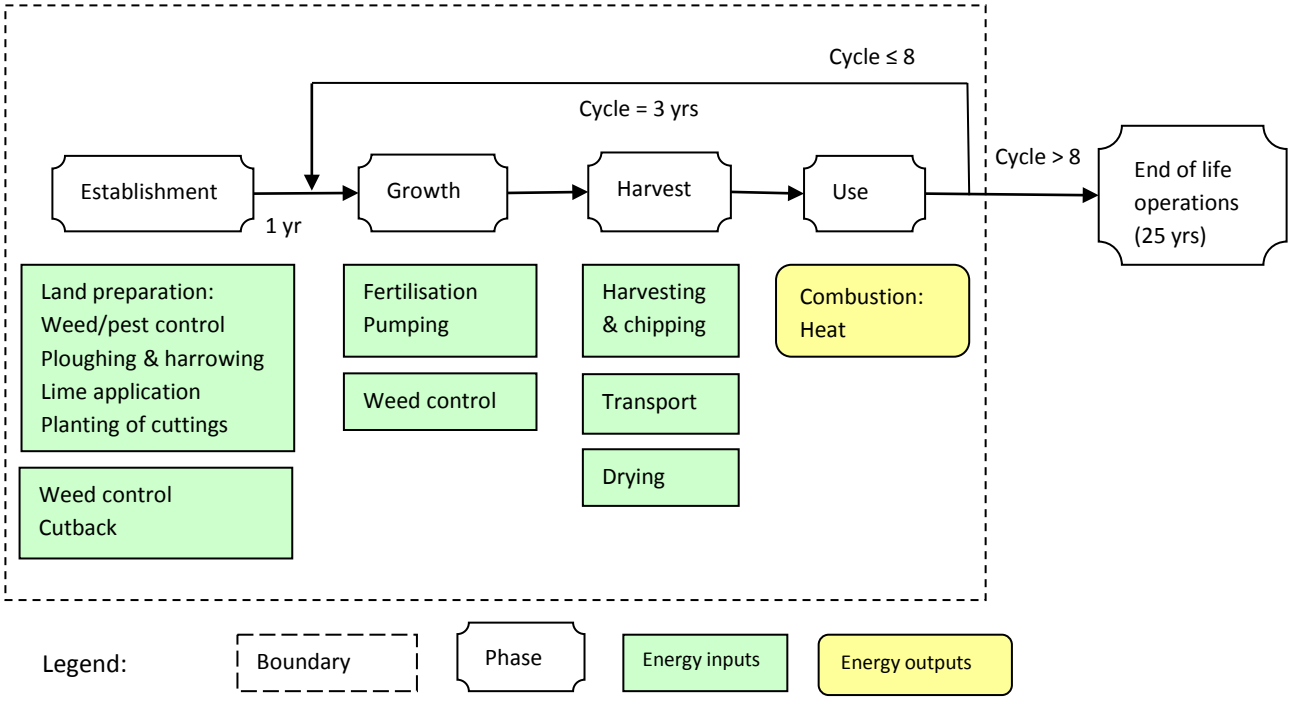
Vehicle manufacture

Indirect transport

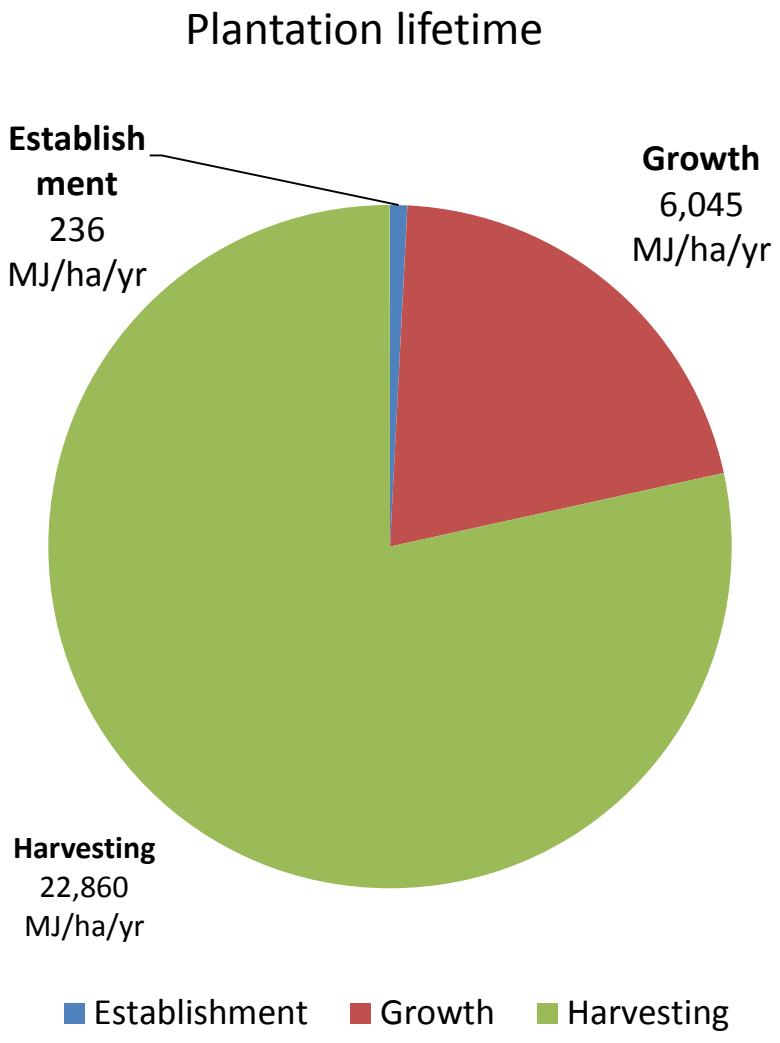
Direct and indirect energy

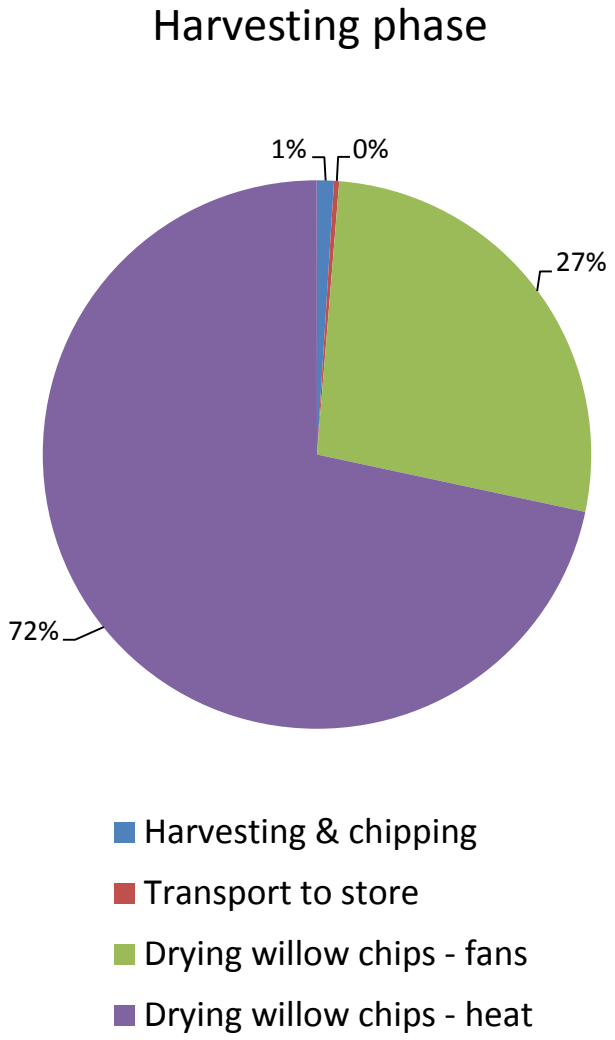
Direct energy
- Used directly in system, e.g. diesel for tractors

Indirect energy
- Used to produce something that is then used in the system, e.g. energy to produce herbicide



Direct energy demand





Hot spots in direct energy demand

Highest direct energy demand is for drying chips

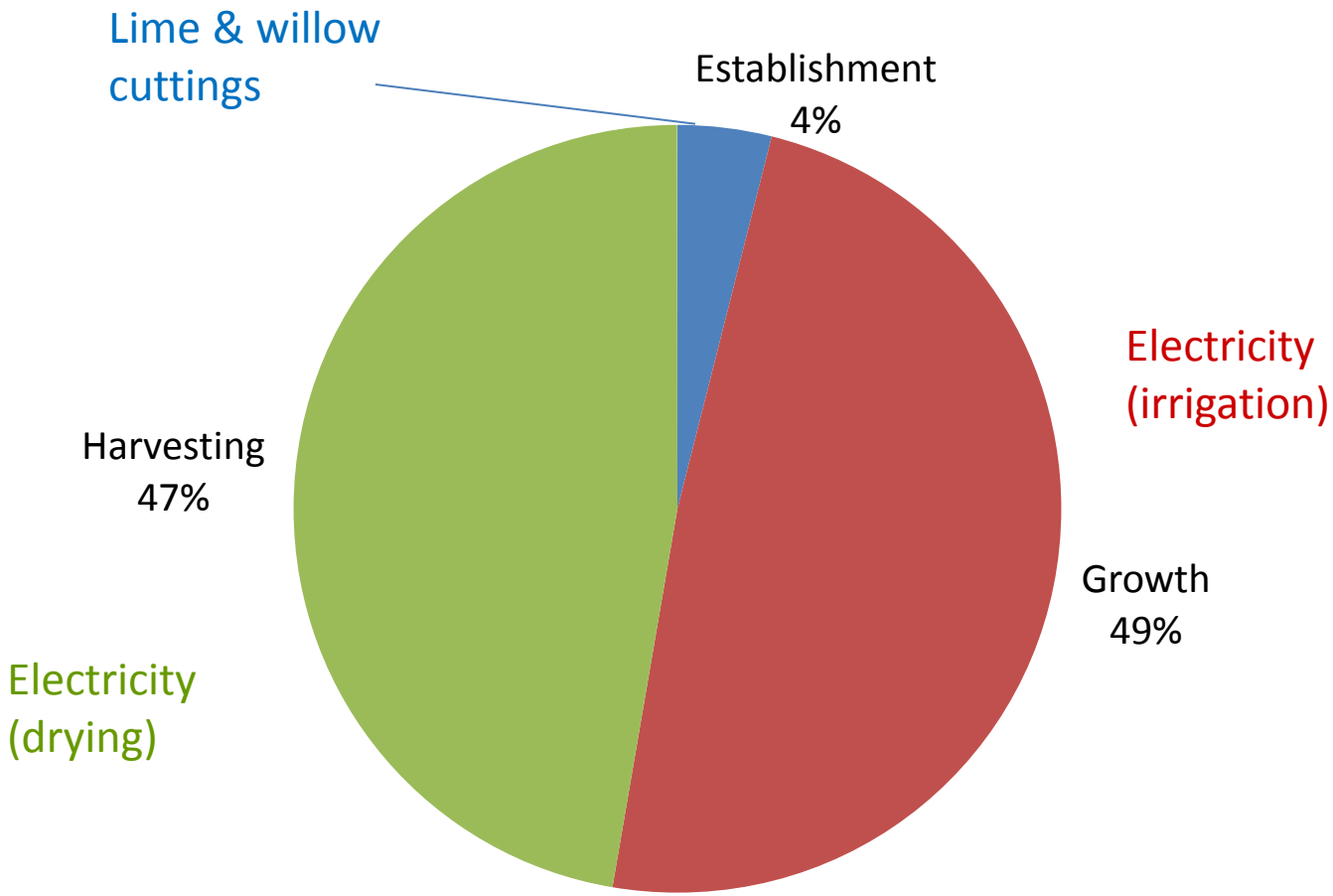
Heat and electricity: >90% of total direct energy
- Electric fans 25%
- Heat 68%

Method
- Willow chip stored in large open air shed
- Electric fans force warm air through floor
- Wood chips used for heat

Tackling the hot spot…
- Design of the drying shed
- Improved ventilation system
- Low-energy drying methods, e.g. whole rod drying under a breathable membrane

Willow drying shed

Indirect energy demand over plantation lifetime



Embodied energy of electricity:

2.07 MJ/MJ (EU mix average for medium voltage)
0.12 MJ/MJ final fuel (offshore wind)

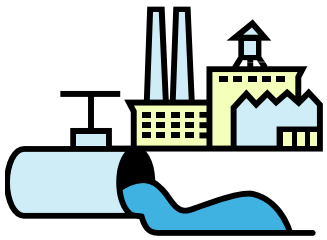
Energy balance over plantation lifetime

	Direct (MJ/ha/yr)	Indirect (MJ/ha/yr)	Direct + indirect (MJ/ha/yr)
Gross energy	209,572	-	209,572
Energy demands			
Establishment	236	1,072	1,308
Growth	6,045	13,281	19,326
Harvesting	22,860	12,877	35,737
Total energy demands	29,141	27,230	56,371
Net energy	180,431	-	153,201
Net/gross energy	86%		73%

Comparison with conventional WWTW

Energy

- Lower concentration of nutrients in wastewater (than in dirty water)
  - Energy demand for pumping increases by factor of four (1.6 MJ/m^3)
  - Direct energy demand increases from 12% to 14% of gross energy
- Net direct energy in willow-wastewater system 48 MJ/m^3
- Energy demand of typical WWTW (NI Water, 2013) 2.6 MJ/m^3



Area

- 1 ha of willow can treat 3884 m^3/yr of domestic wastewater
- 1.17 x 10^8 m^3/yr of wastewater are treated in N Ireland (NI Water, 2014)
- 10% of wastewater could be treated with about 3000 ha of willow
  - which is five times the area currently under the crop in N Ireland (DARDNI, 2013)

Conclusions

- Biggest energy demands are for drying willow chip
  - Direct energy: investigate improvements/alternatives to the ventilation system
  - Indirect energy: switch to wind generated electricity
- Willow is effective for treating wastewater effluent
  - Pumping demand 1.6 MJ/m^3
  - ~60% of the energy required in conventional WWTW
  - Net direct energy is 48 MJ/m^3 of wastewater effluent
- 10% of N Ireland's wastewater could be treated with around 3000 ha of SRC willow

Thank you for listening!

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