Challenges and Limitations of Using SRWC for Energy\(^1\)

The use of Short Rotation Woody Crops for energy poses some challenges. The following are some limitations and challenges of using SRWC.

**INADEQUATE PRODUCTIVITY AND RISK OF PEST AND DISEASES**

One considerable concern about growing SRWCs for bioenergy is that SRWCs may not produce sufficient biomass as a feasible renewable energy source. The US Department of Energy projected that a productivity rate of 17-22 Mg (oven dry) ha\(^{-1}\) yr\(^{-1}\) will be required for the long-term feasibility of renewable production. However, the average production (11.3 Mg (oven dry) ha\(^{-1}\) yr\(^{-1}\)) across site growing conditions in the US and Canada (Fig 1) is well below the required amount of biomass necessary to sustain feasibility of bioenergy systems in the US (English et al., 2006, Hinchee et al., 2009). Pest and diseases also hamper optimum production of SRWCs.

![Fig 1. First rotation biomass yield (Mg (oven dry) ha\(^{-1}\) yr\(^{-1}\)) of top 5 clones with biomass crop yield trials established with new willow genotypes between 1999-2008. Site labels include the year of planting and location (Modified from Volk et al., 2011, Nissim et al., 2013, Zamora et al., 2013).](image)

Potential Solutions

Improve productivity and increase resistance to pest and diseases through breeding program. The following are some recent genetic improvement efforts for SRWC:

a) *Populus* spp.: Companies and research programs in the US and Canada are currently breeding new *Populus* hybrids and varieties with fast growth, high volume increments, and the ability to grow in a wide range of sites that are also resistant to pest and diseases (Table 1). Gene insertion is being employed to improve production. Genomic program investigates development of poplar varieties that can thrive under abiotic stress on marginal land that is suitable for food crops.

b) *Salix* spp.: Willow breeding in the US has been intensified to develop high yielding clones that are also resistance to pest and diseases and could be employed in the landscape for biomass production for energy. Genomic work is underway to investigate how gene expression patterns in willow hybrid are related to yield potential and other traits important for biofuel production.

c) *Eucalyptus* spp.: A genetically engineered hybrid of *Eucalyptus* with genes for cold tolerance, lignin biosynthesis, and fertility is currently in the US regulatory approval process (US DOE, 2011). In field tests, these trees have survived temperatures as low as 6°C. The variety is well known for its high quality fiber and also excels at biomass production and can be planted on marginal lands. Efforts to identify regions of the *Eucalyptus* genome that regulate biomass growth and wood quality are underway to identify genes of value for bioenergy, particularly those involved in the lignin and carbohydrate/cellulose pathways.

Table 1. Currently active Populus spp. breeding programs in North America.

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<th>Company</th>
<th>Location</th>
<th>Region of concentration</th>
<th>Area</th>
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| Greenwood Resource Institute   | Boardman, Oregon, USA           | USA                     | 9,300 ha | - Operating on a 15-year rotation with the output going into the saw log market.  
- Signed an agreement with ZeaChem, a cellulosic ethanol company, to supply them with feedstock from their hybrid poplar farm. |
| Alberta-Pacific Forest Products| Alberta, Canada                 | Canada                  | 8,000 ha | - Growing hybrid poplar trees to feed pulp mills in Alberta, Canada and nearby regions.  
- Ensuring fiber supply availability in response to the deforestation activities in Alberta caused by Tar Sand development. |
| ArborGen                       | USA, New Zealand, Australia and Brazil | Worldwide               |       | - Largest global supplier of seedling products and a leading provider of improved technologies to the commercial forest industry  
- Developing high value products through conventional breeding and genetic improvement.  
- Working to improve the sustainability of working forests while helping to meet the world’s growing need for wood, fiber and energy. |
| University of Minnesota Duluth | USA                             | USA                     |       | - Working to increase yield and genetic diversity of poplar for use as an energy crop |
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- Collecting data from clonal trials, yield tests, spacing trials, and large-scale genetics tests with some locations containing over 900 genotypes.

TECHNOLOGICAL COMPATIBILITY

Technological compatibility issue remains a big challenge in supply chain and logistics of bioenergy production - from harvesting (i.e., matching biomass supply and continuous bioenergy plant demand - to system design (i.e., high levels of complexities and inter-dependencies of bioenergy production systems). Acceptable form of biomass to the end user remains a technological challenge in marketing SRWC. Depending on the equipment, biomass chips may be rendered an inconsistent quality undesirable to the end-user.

Potential Solutions

US and Canada researchers have developed a harvesting system for willow biomass crops based on New Holland (NH) forage harvester fitted with a specially designed willow cutting head to address the issue of harvesting, processing and storing of willow chips for energy (Fig 2). This equipment is now commercially available and the system continues to be improved.

Traditional forestry harvesting equipment needs to be retrofitted to allow for the harvesting of SRWCs in a manner that will optimize production. Several advancements have been made to address logistical needs and companies associated with producing energy from biomass have made modifications to their operations. Materials are chipped onsite to allow for an easy and economical transport of the materials to a facility.

CONVERSION EFFICIENCY

Biochemical (sugar) and thermochemical (pyrolysis or gasification) are two major platforms of converting woody biomass into energy. The deployment of a certain conversion process depends on the wood properties and characteristics. For the biochemical platform of fuel production SRWCs have been seen by some as a less desirable feedstock because of their high lignin content and recalcitrance to digestion, which is one of the challenges in efficiently converting woody biomass to biofuels.

![Fig 2. A New Holland (NH) forage harvester fitted with a specially designed NH FB130 coppice header harvesting four-year-old willow biomass crops in central New York. (Photo D. Angel, SUNY ESF)](image)
Potential Solutions
Use biomass with lignin in a gasification step to produce hydrogen to increase end product yield. Use biomass with natural low levels of lignin and high cellulose for the biochemical process. SRWC is preferred feedstock for the pyrolytic conversion production because of high lignin and greater energy density (US DOE, 2011). Lignin has less oxygen than carbohydrates (so there is less to remove) and higher energy density, meaning more energy content per ton of biomass processed. The low ash content of woody crops may make SRWC the preferred source of raw material in thermal conversion systems.

COST OF PRODUCTION
The high upfront establishment costs, risks associated with the production of new crops, and the uncertainty of biomass markets over multiple rotations have created barriers to the large-scale deployment of Salix, Populus, and Eucalyptus SRWC systems despite their biomass production potential and other associated environmental and rural development benefits (Buchholz and Volk, 2011; Quaye and Volk, 2013).

Potential Solutions
Increasing yields and reducing production costs are considered potential solutions to cost of production. Specific cost-reduction activities will include reducing the cost of planting stock, improving weed control, optimizing harvesting and logistics operations, and reducing input costs such as fertilizer. The use of organic waste materials such as biosolid compost (BC) and digested dairy manure (DM) as nutrient sources for willow biomass production is being explored as an attractive means to decrease fertilization costs, while maintaining nutrient and levels, increasing production, and reducing greenhouse gases associated with the system.

QUESTIONS OR COMMENTS?
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