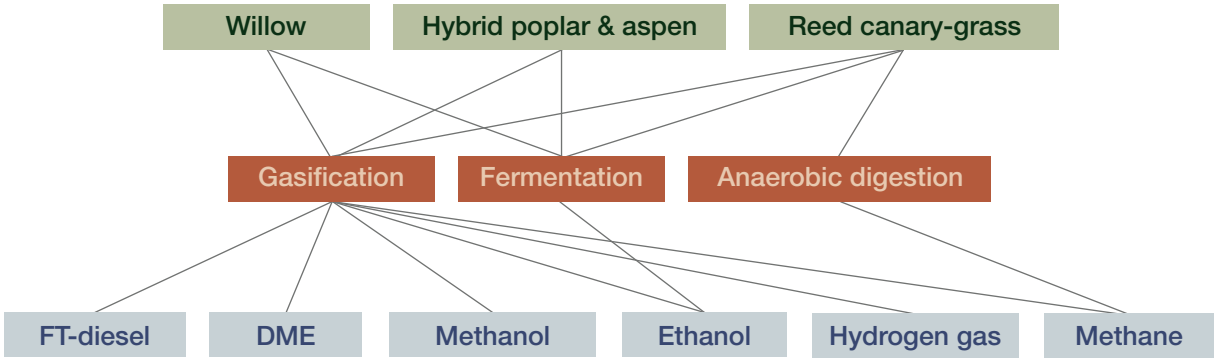
f3 FACTS NOVEMBER 2025 – FEEDSTOCK FOR BIOFUEL PRODUCTION

Energy crops from agriculture: willow, reed canary-grass, hybrid aspen and poplar

Energy crops are crops produced with the objective to be used in the energy system or in combination with production of energy and food & feed. The energy crops presented here are not suitable as food. They include the species willow, reed canary grass, poplar and aspen. These crops can be used to produce a variety of biofuels using different processes according to the flowchart below. By gasification and further treatment, they can be used to produce e.g. methanol, ethanol, DME, hydrogen, Fischer-Tropsch diesel and substitute natural gas (SNG). By fermentation they can be used to produce ethanol and butanol, and by anaerobic digestion to produce methane, although some pre-treatment is required. Another potential lies in the many high-value products that can be co-produced when energy crops are utilized in so called biorefineries. Currently, most of the biomass from energy crops goes to heat and power plants; there is no biofuel production from energy crops in Sweden.



Willow

The genus Salix includes many species and is found wild in all continents except Australia. In Sweden a few species have been selected for breeding programs to form new varieties suitable for growing in different climates. Willow can be grown up to the southern parts of northern Sweden. It needs nutrient rich soil with a pH above 6 and a good supply of water and light to grow well. Clay soils to fine sand soils are appropriate. (Jordbruksverket 2013)

After soil preparation, planting is done from cuttings, and is performed from end of April to middle of June. About 13 000 cuttings per hectare are planted in rows, with more space between every second row to facilitate harvesting. Weed control is very important during the establishment since the weeds compete with the willow plants for light, water, and nutrients. Both mechanical and chemical weed killing is needed during the planting year (ibid). In Sweden, about 5 000 hectares willow were cultivated in 2021 (Skogsstyrelsen 2022), mainly chipped and used for heat and power production.

The use of fertilizers, mainly nitrogen, increase growth significantly. Ideally fertilizing should be done every year but is of practical reasons mainly done the first and second year in each rotation, when the plants are small enough to give access for the spreader. (Aronsson & Rosenqvist 2011)

Harvesting is done during winter every 3-5 years. It is time for harvest when the biggest stems are 7-10 cm in diameter at the base. The output is 20-25 dry tonnes/ha during first harvest and 30-35 dry tonnes/ha onwards.

Common harvesting systems include direct chipping at harvest and harvesting of whole stems. The economic lifetime of a plantation is 20-25 years. (Jordbruksverket 2013)

Reed canary grass

Reed canary grass is a perennial grass that grows wild in wetlands in most of the northern hemisphere and can be grown in all parts of Sweden, also in the north. A well-maintained reed canary grass ley area can be harvested for 10-15 years before new establishment is needed. It can be grown in most kinds of soils but grows best in wet soils with high organic matter content. When grown in organic soils, spreading of lime or ash may be needed to increase the pH value. Different kinds of soils give the grass different properties. For example, the ash content in the grass is higher when grown in clay soils (Jordbruksverket 2011). In 2024, about 400 hectares of reed canary-grass were cultivated in Sweden for energy purposes[1].

Preparation of the land includes ploughing and weed killing before sowing. Weed killing during the first year of growth may also be necessary. Sowing is done in early spring for the grass to establish properly before autumn (Jordbruksverket 2011).

Harvesting is done either in spring or autumn. The first harvest is done in the second year, and then every year onwards. The output is 4-6 dry tonnes/ha. Harvesting in the spring gives a brittle grass with low moisture content, and no further drying is needed. The amount of potassium, chlorine, phosphorus, and nitrogen is also lower in the spring, resulting in lower ash content and higher ash melting point, which makes the feedstock more appropriate for combustion purposes. Harvesting in the autumn gives a higher yield, but the moisture content is also higher. This would be more appropriate for biogas production (Jordbruksverket 2011).

The need for fertilizing is largest the first two years. Autumn harvesting removes a lot of nutrients together with the grass. If the harvesting is done in the spring instead, most of the nutrients are in the roots and are left on the field. Therefore, less fertilizing is needed if a system with spring harvesting is used (Jordbruksverket 2011).

Hybrid aspen and poplar

The genus *Populus* includes about 30 species and grows wild in most of the northern hemisphere. They are commercially interesting since they grow fast and can reproduce from cuttings. As energy crops, different kinds of hybrid varieties are used. They grow best on farmland or fertile forest land, in soils with a pH between 5.5 and 6.5. Nutrient rich light clay soils are suitable. Locations that are exposed to frost during the establishment period should be avoided and there need to be a good supply of water (Skogforsk 2011).

Preparation of the soil includes loosening to allow the roots to grow deeper and weed killing. Weeds can compete with the plants and reduce growth but also constitute a favourable environment for voles, which can cause significant damage to the plants. Especially aspen is also very popular to deer, and fencing is often necessary (Skogforsk 2011).

Planting is made from rooted cuttings, preferably in spring. The number of plants and the management during the growing period is determined by the intended use of the biomass (energy, pulp and/or timber). Suggested rotation time for energy use is 15-20 years, and felling is done with traditional forestry techniques. Growth is 5-9 dry tonnes/ha and year. (Skogforsk 2011, Jordbruksverket n.d.)

After felling, shoots develop in large amounts, which can be used to establish a second-generation plantation, either by keeping all the shoots and after a few years harvest them, or by continuous thinning to establish a new plantation with sparser stems. The latter however is very labour intensive.

About 3 000 hectares poplar and aspen were cultivated in Sweden in 2021 (Skogsstyrelsen 2022).

Sustainability criteria

The EU Renewable Energy Directive (Directive 2018/2001) contains sustainability criteria for land used to produce solid, liquid and gaseous biofuels. The latest revision of the Renewable Energy Directive, that entered into force in November 2023 with an implementation in Swedish legislation in 2025, stipulates that biofuel feedstock must not originate from areas of land with high biodiversity or of high carbon stock or from peatland (European Parliament and the Council 2023).

Chemical properties

These are the chemical properties of the selected energy crops, their mean value and range (given in parenthesis). (Source: Phyllis database[2])

	Willow	Reed canary-grass	Hybrid aspen and poplar
Lower heating value (MJ/kg_{dm})[3]	18 (18-19)	17 (15-18)	19 (18-20)
Ash content (%)	1.8 (0.5-4.6)	6 (1.4-13)	1.2 (0.2-2.7)
Lignin (%)	26 (25-26)	4.6 (4.0-5.3)	23 (16-32)

[1] Jordbruksverket 2025, e-mail communication with the decision support unit the 22 May 2025
[2] European Commission 2013 https://knowledge4policy.ec.europa.eu/dataset/beo-ecnphyllis_en
[3] dm = dry matter, i.e. represents the weight percentage of dry material (including ash)

References

Aronsson, P. & Rosenqvist, H. (2011). *Gödslingsrekommendationer för Salix 2011*. SLU, Institutionen för Växtproduktionsekologi,
https://pub.epsilon.slu.se/8466/1/aronsson_p_111125.pdf

European Parliament and the Council (2023). *Directive 2023/2413 of 18 October 2023 amending Directive (EU) 2018/2001, Regulation (EU) 2018/1999 and Directive 98/70/EC as regards the promotion of energy from renewable sources, and repealing Council Directive (EU) 2015/652*.
https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:L_202302413

Jordbruksverket (2011). *Energigräs – en kunskapssammanställning*.
https://www2.jordbruksverket.se/webdav/files/SJV/trycksaker/Pdf_ovrigt/ovr254.pdf

Jordbruksverket (2013). *Handbok för salixodlare*.
https://www2.jordbruksverket.se/webdav/files/SJV/trycksaker/Pdf_ovrigt/ovr250v2.pdf

Jordbruksverket (n.d.) *Handbok för odlare av poppel och hybridasp.*
https://www2.jordbruksverket.se/download/18.427773ab14dde0f110dae145/1434110736268/ovr355.pdf

Skogsstyrelsen 2022. *Underlag för ökad kolsänka*. Regeringsuppdrag. Rapport 2022/14.
https://www.skogsstyrelsen.se/globalassets/om-oss/rapporter/rapporter-2022202120202019 2018/rapport-2022-14-underlag-for-strategisk-planering-for-okad-kolsanka.pdf

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Industry, universities, institutes, and authorities participate in f3. Together, the members create new collaborations, increase knowledge, and identify obstacles and possible solutions for an actual and rapid transition to renewable fuels in the transport sector.

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