# Projekt LF in MuSuNI

## First of its kind

*Creation and harmonization*
*of landscape and energy production*

GNN-WNN GmbH

GNN – WNN / Global Nature Network – World Nature Network ®

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**Abstract:**

Living fences unite in a harmonized concept the increase in biodiversity, prevention, preservation and build-up of valuable top soil and the generation of renewable energy. Simultaneously to reduced use or elimination of biocides the crop yield and quality of agricultural plants are increased. Living fences are incorporated in larger areas (e.g. agriculture) in a structured manner, which enables sustainable areal use. The concept is globally scalable and addresses 10 out of 17 United Nations Sustainable Development Goals (see Fig. 1). In addition, this concept supports regional employment and the establishment of new regional economic opportunities, enabling sustainable development.

*Figure 1: Presentation of the 17 United Nations Sustainable Development Goals. The ten goals addressed in this living fence concept are highlighted.*

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# 1 Introduction – Project description

This project unites a novel comprehensive living fence concept incorporating an increase in biodiversity, a reduced deployment of biocides, water management, preservation and raise of topsoil, and the generation of renewable energy. We fully address 4 of the 17 United Nations Sustainable Development Goals (SDG) and to a great extent six more SDGs. The GNN-WNN GmbH company (GNN-WNN / Global Nature Network – World Nature Network®)[1] has been founded in order to support these goals and establish this novel living fence concept globally for the provide ecological service in the order of several hundred million Euro annually. The global demand for ecological investments preserving and re-establishing valuable biodiversity in accordance with the Global Biodiversity Frameworks[2] is estimated to demand annually $ 1 billion.[3]

In this concept living fences are incorporated in a structured manner into larger areas (e.g. agricultural fields, real estate and real property, and along infrastructure for transportation) and in urban areas. This close-meshed provides a resilient infrastructure adaptable for many grid types and energy carrier. The original land usage is retained through the small required floor space.

In regard to agriculture the faunistic effect[4] is of prominet interest, which is regarded as state-of-the art and proven and established through many applications (e.g. reports from UK[5], The Netherlands[6] and Poland[7]). They concluded a significant increase of biodiversity and reduction (and even elimination) of biocide use through the implementation of flower strips. Simultaneously there was an increase in the amount of beneficial organisms for pollination and pest control. This in turn provided a reduce in stress factors and crop pest for the agricultural plants, increasing their nutritious quality. Despite a reduced area for agricultural use, a higher yield (up to 17.9 %) could be achieved, accompanied by a higher soil humidity. Additionally installed living fences provide protection against wind which prevents soil erosion and supports the build-up of humus layer and rank top soil. The plants incorporated in the living fence are chosen based on the regional and climatic contidtions to ensure the best possible expression of the faunistic effect. Our concept is, thus, tailored to most appropriately serve the enhancement of lokal soil quality.

When applicable, there is a water polder incorporated in the living fence concept. It serves as an important part for water management, regulating the channel flow and water storage, especially in case of extreme water events. The water polder achieves a positive effect on groundwater.

Incorporated photovoltaic installations generate renewable energy. Depending on the specificity of agricultural or commercial use of the area, a variety of different types of photovoltaic modules can be installed. These may be flexible modules, bifacial modules, organic foils, full-area modules or semi-transparent modules. First and foremost is the generation of renewable energy and its decentralized utilization. This principle shall prevent shutdown due to grid congestion or missing connections to the grid. Renewable generated energy may be utilized in a variety of ways, depending on the area of installation, demand and economic aspects. One possible option is the

1 GNN-WNN GmbH / Project LF | F6S
2 Kunming-Montreal Global Biodiversity Framework | UNEP - UN Environment Programme
3 BNEF (Opportunity Blossoms – The Business of Curbing Nature Loss, BloombergNEF, 25. October 2024)
4 faunistische-evaluierung_bluehflaechen_lfl-schriftenreihe-1-2014.pdf (bayern.de)
5 ASSIST End of Programme event | UK Centre for Ecology & Hydrology (ceh.ac.uk)
6 WOCAT SLM Technologies
7 Agronomy 2020, 10, 1696; doi:10.3390/agronomy10111696

conversion of electric energy in chemical energy through electrolysis. Water is provided through a desalination apparatus and subsequently split into hydrogen (and oxygen). Hydrogen could be used as such as an energy carrier or stored and transported in liquid organic hydrogen carrier (LOHC) systems.[8] A hydration reactor and appropriate storage facilities are then installed. Storage and transport of liquid substances is established and is used to transport the LOHC to the point of hydrogen demand (e.g. steel mills, chemical industry).
Further options for decentralized applications of the renewable energy incorporate the production of methanol or storage in stationary energy storage systems (electric, thermal, gravimetric).

The living fence concept furthermore provides a variety of options for the integration of sensors to serve a wide range of requirements (e.g. observation of weather and ecological factors, observation as such, mobile telecommunication). Ductwork for cables is submerged underground to provide room for the incorporation of the desired application.

The concept of living fences is highly scalable and suitable for the application in larger areas, urban areas and along transportation infrastructure. The incorporation of plants is tailored to the specific climatic and regional conditions, thus adaptable world wide. The concept provides positive ecological effects, generation of renewable energy and allows to use the areas in harmony with the original manner → Win-Win!

Our concept addesses 10 of the 17 United Nations sustainable development goals[9], four out of them fully and additional six to a large extent (see Fig. 2).

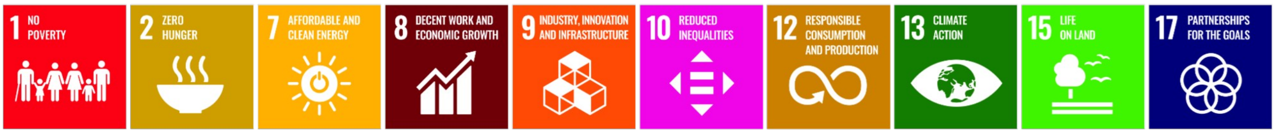

*Figure 2: This concept addresses 10 of the 17 United Nations Sustainable Development Goals (SDGs).*

**1 – End poverty in all its forms everywhere**
World wide scalability of our concept supports employment through installation and service of the living fences and its facilities.

**2 – End hunger, achieve food security and improved nutrition and promote sustainable agriculture**
The faunistic effect of the living fences increases crop yield and simultaneously reduces or eliminates the application of biocides. This serves greatly the regional and global food security and sustainable soil use.

**7 – Ensure access to affordable, reliable, sustainable and modern energy for all**
Installed photovoltaic modules provide renewable energy and provide reliable supply of energy when combined with suitable energy storage.

**8 – Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all**

8 Hydrogenious LOHC Technologies
9 THE 17 GOALS | Sustainable Development

The living fence concept is scalable globally and serves sustainable economic development in the respective region. Upon establishment, local resources and manufacturing are preferred.

**9 – Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation**

A sustainable economic local development of local value chain is supported. The renewable energy may provide grid service, supply off-grids with electricity, generation of hydrogen for energy storage or industrial use, or supply and storage of thermal energy, respectively.

**10 – Reduce inequality within and among countries**

The living fence concept is strongly focussed on agricultural applications which are often regions of less economic development. Thus, new economic opportunities arise through the generation of renewable energy and its marketing as electricity, hydrogen or heat. This reduces economic inequality within and among countries.

**12 – Ensure sustainable consumption and production patterns**

The faunistic effect and the integrated water management sustainably support agricultural production processes. The use of biocides is reduced or eliminated fully and crop yield simultaneously increases. This harmonizes agricultural land usage with sustainable ecological preservation of the soil. Water management supports in addition the natural hydrologic balance.

**13 – Take urgent action to combat climate change and its impacts**

The concept of living fences provides immediate positive effects to combat climate change: Living fences reduce soil erosion and enhance the preservation and build-up of top soil. An integrated water polder supports the natural hydrologic balance in soil, preventing desiccation and marshiness. Flower stripes greatly benefit the settlement of useful animals which significantly reduce or fully eliminate the use of biocides. This supports the harmonization of the ecological balance. All this serves to prevent and reverse the outcomes of climate change and preserves and supports the build-up of rank top soil. Furthermore, does the renewable generated energy reduce the carbon-footprint of economic activity.

**15 – Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss**

Sustainable use of agricultural areas in harmonious combination with the generation of renewable energy is the core of the present concept of living fences. One top outcome is the increase and re-cultivation of biodiversity through structural integration of flower stripes. They provide and recreate a natural habitat for useful animals.

**17 – Strengthen the means of implementation and revitalize the Global Partnership for Sustainable Development**

The concept of living fences is globally scalable and opens up additional opportunities for global collaboration and sustainable regional development. Economic opportunities are provided through marketing renewable energy in various ways. Opportunities for employment and value chain development are arising upon installation and service of the living fences, which supports and fosters economic relations.

# 2. Cost calculation

## 2.1 Cost for fence units

The following table (Tab. 1) provides an overview of the various items that make up one fence unit, including the installed solar modules. The solar modules are exemplified by a product from Sunman Energy (520 Wp, 2246 mm x 1123 mm).

*Table 1: Cost breakdown for items making up one fence element (orange CapEx, gree OpEx).*

| Category | Items | Unit cost / € | Amount per unit | Cost / € |
|---|---|---|---|---|
| **Material** | **Scion** | 0.50 | 50.00 | 25.00 |
| **Material** | **Soil & clay (planting box)** | 70.37 | 1.00 | 70.37 |
| **Material** | **Planting box (50x50x5000 mm)** | 150.00 | 1.00 | 150.00 |
| **Material** | **Clay for polder** | 1242.71 | 0.50 | 621.35 |
| **Material** | **Seeds** | 3.33 | 1.00 | 3.33 |
| **Material** | **Drip irrigation** | 2.91 | 1.00 | 2.91 |
| **Material** | **Duckwork** | 19.00 | 4.00 | 76.00 |
| **Material** | **Supporting material** | 25.00 | 1.00 | 25.00 |
| **Material** | **Solar modules** | 320.00 | 12.00 | 3840.00 |
| **Material** | **Frame for solar modules** | 400.00 | 1.00 | 400.00 |
| **Material** | **Electrical installation** | 100.00 | 1.00 | 100.00 |
| **Humen resource** | **Working hours** | 40.00 | 25.00 | 1000.00 |
| **Machine** | **Machine hours** | 50.00 | 1.25 | 62.50 |
| **Machine** | **Special machine** | 50.00 | 1.00 | 50.00 |
| **other** | **Special goods** | 250.00 | 1.00 | 250.00 |
| **other** | **Storage** | 12.00 | 1.00 | 12.00 |
| **other** | **Administration** | 150.00 | 1.00 | 150.00 |
| | | | **Sum / €** | **6838.47** |

The cost for the compilation of one fence unit is estimated to **6.838,47 €.** The cost for solar modules has the highest share of the total cost, as presented in Fig. 3.

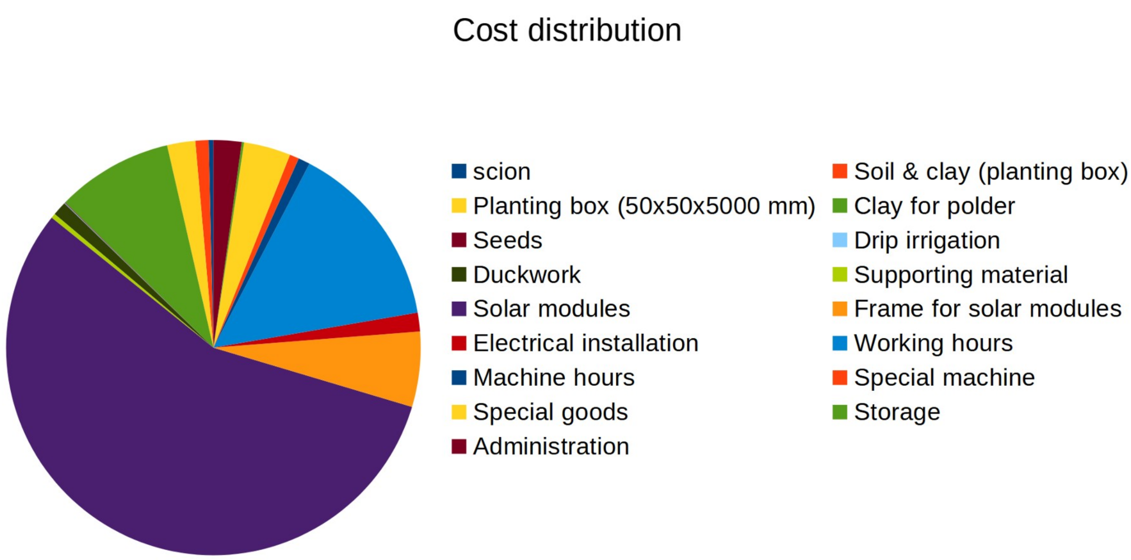


*Figure 3: Graphical representation of the cost distribution for the creation of one fence unit.*

## 2.2 Cost distribution for the First-of-its-Kind Project

Table 2 comprises the estimated cost items for the First-of-its-Kind Project in Spain. It includes the installation of living fences on an area of 1 $km^2$ and the required equipment to convert the renewable energy into hydrogen (stored in liquid organic hydrogen carrier (LOHC)), these are water desalination and purification, electrolysis, hydration, storage for LOHC, and battery energy storage). The solar modules chosen for this calculation are the ones with the highest power rating. Various other types of solar modules can be found in Tab. 3.

*Table 2: Cost distribution and KPIs for the implementation of the living fence concept on an area of 1 $km^2$.*

| | | |
|---|---|---|
| | Number of fence units | 6400 |
| | Number of solar modules | 76800 |
| | **Cost of fence units / k€** | **43766.18** |
| **KPI** | | |
| **Solar production** | Installed power / kWp(DC) | 39936.00 |
| | Energy / kWh/d | 167731.20 |
| | Power / kW(AC) | 29802.99 |
| **Energy storage** | Battery storage / kWh | 223642 |
| **Energy losses** | Loss through transportation / kWh/d | 4528.74 |
| | Loss through storage / kWh/d | 14642.93 |
| | Loss at components / kWh | 16773.12 |

| | | |
|---|---|---|
| **Available Energy** | Available Energy / kWh/d | 131786.40 |
| **Energy demand** | Energy for Electrolysis / kWh/d | 121487.88 |
| | Energy demand water purification / kWh/d | 54.67 |
| | Energy demand hydration / kWh/d | 38.88 |
| **Energy productin** | Thermal Energy / kWh/d | 25755.43 |
| **Electrolysis** | H2-Productino per day / kg-H2/d | 2429.76 |
| | H2-Production per day / Nm3-H2/d | 27027.34 |
| | H2-Production per day / mol-H2/d | 1214878.77 |
| | Amount of water / kg/d | 21867.82 |
| | Volume of water / dm3/h | 911.16 |
| | PEM rating / kW | 6032.52 |
| **Hydration** | Mol DBT / mol/d | 134986.529 |
| | Amount DBT / kg/d | 43388.527 |
| | Volume DBT / dm3/d | 42705.243 |
| **Catalyst** | Catalyst demand (Pt/Al2O3) for daily production/throughput / kg | 187.48 |
| | **CapEx** | |
| | CapEx fence units / k€ | 34009.38 |
| | Estate/Land / k€ | 2000 |
| **Hydration** | Material / k€ | 433.89 |
| | Reactor / k€ | 11628.13 |
| | Storage / k€ | 39.05 |
| **Electrolysis** | PEM Reactor / k€ | 10858.54 |
| **Reverse osmosis** | Water purification / k€ | 15.5 |
| | Water desalination / k€ | 43.7 |
| **Battery storage** | Battery storage / k€ | 55910.40 |
| **Solar module installation** | Installation/Planing/Comissioning/ Components / € | 14167.88 |
| | **Sum CapEx / k€** | **129106.50** |
| | **OpEx** | |
| | OpEx fence units / k€ | 9756.80 |
| **Hydration** | Catalyst cost (Pt/Al2O3) / k€ | 28.12 |
| **Water purification** | Water purification / k€/y | 18.60 |

| | | |
|---|---|---|
| **Lease/rental** | 1000 m2 rent storehouse / k€/y | 35.00 |
| | 500 m2 rent Container / k€/y | 65.00 |
| | Lease / k€/ha*y | 1.90 |
| **Overhead cost** | Transport and logistics / k€ | 10328.52 |
| | Project management / k€ | 2582.13 |
| | Consulting/project development/planning | 3873.20 |
| | Permission/Expertise / k€ | 500.00 |
| | Commissioning / k€ | 100.00 |
| | Insurance / k€ | 7819.79 |
| | Risk budget / k€ | 16421.56 |
| | Financing / k€ | 903.19 |
| | **Sum OpEx / k€** | **52433.80** |
| | | |
| | **Sum / k€** | **181540.30** |

Summary of cumulated costs for the First-of-its-Kind Project:

- **CapEx: 129.106,50 k€**
- **OpEx: 52.433,80 k€**

- **Total: 180.540,30 k€**

## 2.3 Production cost:

**Electricity generation: 0,124 €/kWh** (Including a battery energy storage system with a capacity of 1.2 times daily energy production and depreciation of 20 years, cost composition: 82 % CapEx and 8 % OpEx)
**Hydrogen production (from electrolysis): 8,645 €/kg-$H_2$** (Includes depreciation of 20 years, cost composition: 8,1 % CapEx and 91,9 % OpEx)
**Hydrogen production (stored in LOHC (DBT)): 10,875 €/kg-$H_2$** (Includes depreciation of 20 years, cost composition: 0,4 % CapEx and 99,6 % OpEx)

## 2.4 Assumptions and Conditions

**Comparison of different types of solar modules:**

Table 3 lists various different types of solar modules, in which the areal power rating, price per power rating and the resulting installed power rating per living fence unit can be compared.

*Table 3: Overview over different types of solar modules and their KPIs*

| Solar module type | Areal power rating / Wp/m$^2$ | Cost per power rating / €/Wp | Power per fence unit / Wp/fence unit |
|---|---|---|---|
| **Organic Photovoltaic** (foils) e.g. from Heliatek | 72,0 | 1.67 | 2700 |
| **Thin, light and bendable** Solar modules e.g. from Sunman Energy | 206,2 | 0.62 | 6240 |
| **Solar module** e.g. from Meyer Burger | 212,0 | 0.44 | 5850 |
| **Semi-transparent Solar module** e.g. from Britesolar | 69,5 | 1.00 | 2250 |

**Energy:**

- Energy demand electrolysis per kg-$H_2$: **50 kWh/kg-$H_2$** (Fraunhofer ISE Studie "Cost Forecast for Low Temperature Electrolysis Technology Driven Bottom-Up Prognosis for PEM and Alkaline Water Electrolysis Systems", 2021)
- Energy demand electrolyser per kg-$H_2$: **4.2 kWh/kg-$H_2$** (DOE Hydrogen Program Record 24005: Clean Hydrogen Production Cost Scenarios with PEM Electrolyzer Technology (energy.gov) )
- Energy demand for hydration per kg-$H_2$: **0.016 kWh/kg-$H_2$** (https://doi.org/10.1016/j.isci.2021.102966 )
- Energy production during hydration per kg-$H_2$: **10.6 kWh/kg-$H_2$** (https://doi.org/10.1016/j.isci.2021.102966)
- Solar modules from Sunman Energy with a power ration per module: **520 Wp** (Sunman | Pioneer of Ultra-Light Solar (sunman-energy.com) )
- Solar modules from Meyer Burger with a power ration per module: **390 Wp** (Solarmodule von Meyer Burger | Zellen und Module Made in Germany )
- Semi-transparent solar modules from Britesolar with a power ration per module: **150 Wp** (Products (britesolar.com) )
- Solar foils (organic photovoltaic) from Heliatek with a power ration per module: **360 Wp** (HeliaSol (heliatek.com) )
- Solar intensity and average yield per power rating: **2.8 Wh/Wp** (Germany), **4.2 Wh/Wp** (Spain) (https://globalsolaratlas.info/)
- A battery energy storage system with **1.2-times the daily production capacity** is included, to ensure continuous energy delivery for the down-steam hydrogen production equipment.
- The applied amount of LOHC (her DBT) is assumed to be **three times the daily production**.
- Storage of hydrogen in DBT: **0.056 kg-$H_2$/kg-DBT** (https://ec.europa.eu/research/participants/documents/downloadPublic?documentIds=080166e5c551f4c2&appId=PPGMS)

**Physico-chemical constants:**

- Density of hydrogen: 0.0899 kg/m$^3$
- Molar mass of hydrogen ($H_2$): 2 g/mol

- Molar mass of water: 18 g/mol
- Density of water: 1 g/cm$^3$
- Mol $H_2$ for hydration of dibenyltoluen (DBT): 9
- Molar mass DBT: 272.38 g/mol
- Density of DBT: 1.044 g/cm$^3$
- Catalyst productivity: 0.54 kg-$H_2$/(kg-cat * h) (https://doi.org/10.1016/j.isci.2021.102966 )
- Catalyst approcimate useful life time: 14,000 h (583.3 d) (https://doi.org/10.1016/j.isci.2021.102966)

**Cost:**

- Cost DBT: **4 €/kg** (https://doi.org/10.1016/j.isci.2021.102966)
- Cost catalyst: **150 €/kg** (https://doi.org/10.1016/j.isci.2021.102966)
- PEM-Electrolyseur: **~1,800 €/kWe** (Electrolysers - Energy System - IEA )
- Reverse osmosis reactor (sea water desalination): **~2,500 €/m$^3$*d** ((PDF) COST MODELING OF DESALINATION SYSTEMS )
- LOHC materials: **5,000 €/t** (https://doi.org/10.1016/j.isci.2021.102966)
- LOHC reactor: **134,000 €/t** (https://doi.org/10.1016/j.isci.2021.102966 )
- LOHC storage: **3,000 €/t** (https://doi.org/10.1016/j.isci.2021.102966 )
- Water purification: **32,100 €** (5000 l/h) (Umkehrosmoseanlage 5 m³/h | Onlineshop (wasseraufbereitung-shop24.de) )
- Stationary battery storage unit: **~250 €/kWh** (U.S. Solar Photovoltaic System and Energy Storage Cost Benchmarks, With Minimum Sustainable Price Analysis: Q1 2023 )
- CapEx for utility PV: **1,300 €/kW$_{AC}$** (Utility-Scale PV | Electricity | 2023 | ATB | NREL ) in our case about 830 €/kW$_{AC}$ are CapEx for solar modules, thus about 470 €/kW$_{AC}$ are assumed for planning, installation, commissioning and electrical equipment
- Operation and maintenance of utility scale PV: **25 €/kW$_{AC}$*y** (Utility-Scale PV | Electricity | 2023 | ATB | NREL )
- PEM reactor, exchange of stacks every 40,000 h of service (~4.5 years): 11 % of CapEx → **~2.44 % of CapEx per year** (DOE Hydrogen Program Record 24005: Clean Hydrogen Production Cost Scenarios with PEM Electrolyzer Technology (energy.gov) )
- LOHC reactor, operation and maintenance: **0.05 €/kg-DBT** (Documents download module (europa.eu) )
- LOHC reactor, labor cost: **0.07 €/kg-DBT** (Documents download module (europa.eu) )
- Lease for land: **170 €/ha*y** (Pachtpreise in Europa: Zwischen den Pachtpreisen liegen Welten | agrarheute.com )
- OpEx for water purification: **2.33 €/m$^3$*y** (DOI:10.3390/en12244651)
- Maintenance and repair cost for PEM: **20 €/kW*y** (Cost Forecast for Low Temperature Electrolysis - Technology Driven Bottom-Up Prognosis for PEM and Alkaline Water Electrolysis Systems )
- Operation, maintenance and repair for electrolyseur (without stack renewal): **5 % of CapEx per year** (DOE Hydrogen Program Record 24005: Clean Hydrogen Production Cost Scenarios with PEM Electrolyzer Technology )

# 3 Business models

## 3.1 Business models

The living fence concept looks at four different business and commercialisation models. The business models A, C, E, G/H are aimed for and favoured. Fig. 4 gives an overview of the four different business model strategies and the costs involved are presented in Tab. 4.

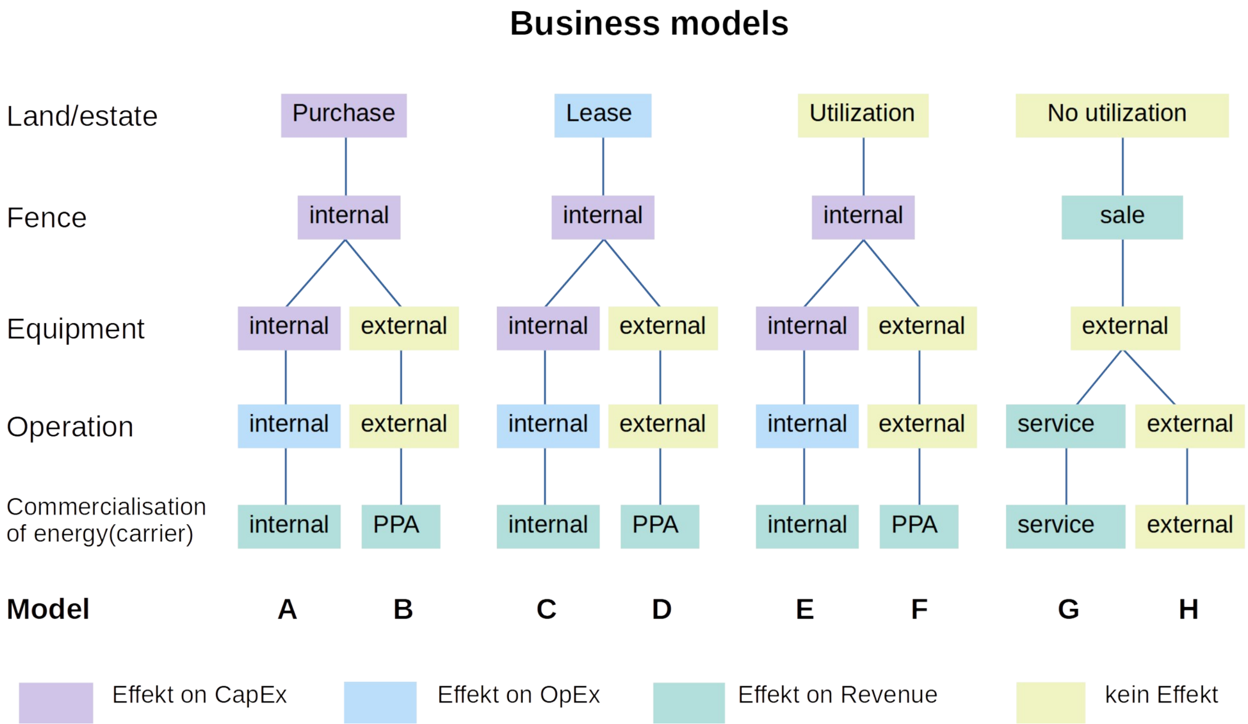


*Figure 4: Overview of the four different business models for the commercialisation of living fences and the generated renewable energy and its products.*

The colours in Fig. 4 represent the effect of the individual components on CapEx, OpEx, Revenue or none of the three.

**Land/estate:** The required land is either bought (A, B), leased (C, D) or provided (E, F). If there is no utilisation from our site (G, H), we sell the living fence units as a product and install them.

**Fence:** The living fences (incl. solar modules) are either used by us (internal) or sold as a product (sale).

**Equipment:** These are the various apparatus for energy conversion and energy storage, as well as conversion into molecules (i.e. electrolyseur, battery storage, etc.). The equipment is either purchased, installed and operated by us (internal) or by another company (external).

**Operation:** The operation of the equipment is either performed by us (internal), by another company (external), or by us as a service (service). OpEx is generated in the first case, none in the second case and a revenue stream is generated in the third case.

**Commercialisation of energy (carrier):** All intermediate and final products are regarded as energy and energy carriers. In our case this is: electricity (renewable from solar energy), hydrogen (as pure product), hydrogen (stored in liquid organic hydrogen carrier (LOHC)), and thermal energy. In case the apparatus are owned by the company (internal), we as well commercialise the energy(carrier) ourselves. Do the apparatus belong to another owner/company, we commercialise our energy (electricity) through power purchase agreements (PPA). We as well offer the commercialisation of energy (carriers) as a service.
Table 4 lists the cost for installation and operation, production of individual energy (carriers) and the expected revenue.

Depending on the local economic environment we offer at least electric energy, hydrogen (pure) or hydrogen (stored in LOHC):

- **Electric energy** can be produced at **0.124 €/kWh** and be soled (incl. margin) at a revenue of **3,269.95 € per day**.

- **Hydrogen (pure, not compressed)** can be produced at **8.645 €/kg-$H_2$** and be soled (incl. margin) at a revenue of **4,200.98 € per day**.

- **Hydrogen (stored in DBT)** can be produced at **10.875 €/kg-$H_2$** and be soled (incl. margin) at a revenue of **5,284.75 € per day**.

**Ecological revenue (not monetised as of now):** A more detailed business model will comprise further revenue from $CO_2$-certification and ecological services.

- ***Pollunation through insects:***
  The ecological service provided by insects on useful plants is estimated to create an annual global value of € 153 billion.[10] Another study, focussing on the USA, these ecological services by insects are estimated of annually US-$ 57 billion.[11]

- ***Purification of ground and surface water:***
  The eutrophication (higher input of nutrients like nitrogen and phosphorous compounds in surface water) was estimated to create a negative impact of € 600 million annually in The Netherlands. Furthermore, the cost for purification of drinking water was estimated to annually € 23 million. The same study concluded an annual cost damage of agriculture on water to amount to € 725 million and annual cost for pesticide removal from drinking water to € 160 million.[12] For Australia the cost damage on water through agricultural activity was determined to an annual amount of AUD 60 million (€ 37.13 million).[13]

- ***Polder function for water management:***
  Estimations of the economic value of a polder function is rather complex. There is a recent

10 Ecological Economics 68 (2009) 810: https://doi.org/10.1016/j.ecolecon.2008.06.014
11 BioScience 56 (2006) 311: https://doi.org/10.1641/0006-3568(2006)56[311:TEVOES]2.0.CO;2
12 International Journal of Water Resources Development 27 (2011) 33: https://doi.org/10.1080/07900627.2010.531898
13 Monetary costs and benefits of agriculture's impact on water systems | Water Quality and Agriculture : Meeting the Policy Challenge | OECD iLibrary

study that looked into Germany and estimated an annual value or 2,000 €/ha.[14]

- ***Natural control of plant pests:***
  A study focussing on wheat fields in south England determined an ecologic service of annually £ 2.3 million (for this region).[15] This would convert into roughly 13.5 €/ha annually.[16]

The realisation of this First-of-a-Kind Project generates global ecologic value!

14 Ecosystem Services 67 (2024) 101615: https://doi.org/10.1016/j.ecoser.2024.101615

15 Ecosystem Services 30 (2018) 149: https://doi.org/10.1016/j.ecoser.2018.02.019

16 Agricultural facts: South East (including London) region - GOV.UK

*Table 4: Overview of cost distribution and expected revenue of the various business cases. The OpEx cost from “storageroom” to “financing” from Table 2 are included in models B, D, F, G and H .*

| Business model | A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|---|
| **Cost for Installation and Operation** | | | | | | | | |
| **Sum CapEx / k€** | 129106.50 | 36009.38 | 127106.50 | 34009.38 | 127106.50 | 34009.38 | 34009.38 | 34009.38 |
| **Sum OpEx / k€** | 52619.07 | 23361.24 | 51997.93 | 22740.10 | 51995.72 | 22737.89 | 22737.89 | 22737.89 |
| **Sum / k€** | 181725.57 | 59370.63 | 179104.43 | 56749.48 | 179102.22 | 56747.27 | 56747.27 | 56747.27 |
| **Production cost** | | | | | | | | |
| **Electricity / €/kWh** | 0.124 | 0.066 | 0.122 | 0.064 | 0.122 | 0.064 | 0.000 | 0.000 |
| **Hydrogen (Electrolysis) / €/kg-H2** | 8.645 | 0.000 | 8.513 | 0.000 | 8.511 | 0.000 | 0.000 | 0.000 |
| **Hydrogen (in LOHC) / €/kg-H2** | 10.875 | 0.000 | 10.743 | 0.000 | 10.741 | 0.000 | 0.000 | 0.000 |
| **Revenue** | | | | | | | | |
| **Electricity / €/kWh** | 3269.949 | 1738.158 | 3216.198 | 1684.406 | 3215.155 | 1683.363 | 0.000 | 0.000 |
| **Hydrogen (Electrolysis) / €/kg-H2** | 4200.984 | 0.000 | 4137.042 | 0.000 | 4135.999 | 0.000 | 0.000 | 0.000 |
| **Hydrogen (in LOHC) / €/kg-H2** | 5284.751 | 0.000 | 5220.793 | 0.000 | 5219.750 | 0.000 | 0.000 | 0.000 |

*There might be slight differences in CapEx and OpEx in comparison to what is presented in Table 2, since there land purchase and lease are presented together and are separated here. Since the costs for both of them are (in comparison to the total cost) small, the values in Table 2 are kept in that way.*

## 3.2 Service

The concept of living fences provides a high value for ecology and services therein. Furthermore, there are a number of different services to be provided which can be tailored to the individual economic environment of the region and customer where the living fences are installed.

### 3.2.1 Ecology services

Living fences, and in particular the incorporated flower stripes, provide a habitat for a number of useful animals. Consequently the use of pesticides in agriculturally used land is significantly reduces if not eliminated completely. This, furthermore, protects other insects and animals in their natural habitat and creates a positive impact on the ecosystem as such. The polder function supports the natural water balance and provides storage and irrigation functions. This is a positive impact on the natural water balance for ground and surface water. Living fences provide wind shadow preventing soil erosion and significantly preserve top soil quality. The solar panels of three times 25 m2 for two fence units provide valuable shadow, preventing evaporations upon strong solar irradiation. The cumulative effect of the ecological services supports as well the increase and preservation of humus layer.

### 3.2.2 Grid services

The concept of living fences harmonises the use of land (e.g. agricultural) and generation of renewable energy. The built-in energy storage systems may provide valuable grid services of different kinds and are as well applicable for Smart Grid applications. Off grid services for island networks an be provided in rural areas.

Furthermore, there are a number of services that can be provided through the stable and continuous generation of decentralised renewable energy. This may include telecommunication devices, surveillance (e.g. meteorology, ecology, or observation relevant for security purposes).

### 3.2.3 Energy and energy carrier

The availability of decentralised renewable energy may be utilised in various forms. Depending on the economic demand and feasibility of the region:

- **Electrical energy:** For chargers (mobility), industrial activity, island grids, ...
- **Hydrogen (pure):** Sold as pure product (compressed), long-term energy storage, fuel for mobility application, feed in in pipelines, ...
- **Hydrogen (stored in LOHC):** Hydrogen stored in liquid organic carriers (LOHC), these liquids can be transported easily (proven technology) to points of industrial use (e.g. metallurgy, chemical processes, refinery, heating).
- **Thermal energy:** Storage of thermal energy in “thermal batteries” for decentralised delivery of heat (for industrial purpose, residential heating).
- **Methanol:** In combination with captured CO2 from biogas processes, methanol may be synthesized decentralised. It may be used as a fuel for mobility applications or as a base molecule in chemical industry.