### Deliverable No. 4.3

**Business models for 3 technologies for sustainable water use in fertigated crops**

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Transfer of INNOvative techniques for sustainable Water use in FERtigated crops

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Transfer of INNOvative techniques for sustainable Water use in FERTigated crops

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1 Executive summary

The aim of Work Package 4 is to stimulate transfer of innovative technologies to the horticultural sector, bringing the current state-of-the-art, as benchmarked in FERTINNOWA growers’ survey (D3.3) to the next level. The deliverable report D4.3 focusses on the development of business models for 3 innovative technologies supporting sustainable water and nutrient use in fertigated crops.

The selection of the 3 cases built on the outcomes of other FERTINNOWA actions:

1. The Benchmark survey (D3.3) identified the current state-of-the-art regarding irrigation and fertigation practices and management. The survey showed the technologies used as well as the bottlenecks faced by the growers, and the triggers and thresholds to implement (new) technologies.

2. The Reference Document (D3.4), further referred to as Fertigation Bible, provided an overview of technologies currently used in the fertigated sector and also, a series of technologies that show high potential for the fertigated sector but are not yet implemented at the farms.

3. The report on the identification of gaps (D4.1) explained in more detail the remaining gaps at the technological, socio-economic and legal level.

4. The report on scouting new technologies (D4.2) in other sectors provided an overview of technologies with the potential to solve gaps identified in D4.1.

5. Evaluation report of the on-site implementation of technologies to improve water use efficiency in for soilless crops (D5.4).

Based on these project outcomes the following cases were selected:

1. The Electro-dialyses technology as provided by the Dutch SME Water Future. The benchmark survey and the D4.1 report showed that there is a need for technologies to selectively remove sodium from irrigation and/or recycled drain water. The technology of Water Future allows semi-selective removal of sodium. The Dutch SME Water Future was interested in collaborating with FERTINNOWA to investigate the potential of their technology in Europe.

2. The Sodium Removal Unit (SRU) from the South African SME Optima Agrik. Also, this technology focusses on the selective removal of sodium. Additionally, the SRU, which is based ion exchange allows recovery of nutrients. The experiences achieved during the exchange of the SRU technology in WP5 had been very promising (cfr.5.4). Therefore, the SRU technology was selected to explore its potential for the fertigated sector in T4.3 further.

3. The IRRIX Decision Support System (DSS) for irrigation and fertilization recommendations. In recent years, some DSS have been developed. The Benchmark survey showed that DSS systems were mainly applied in soil-grown outdoor cropping systems in the Mediterranean region (62% of the respondents) and soilless covered cropping systems, mainly in the North West region (38% of the respondents). Nevertheless, D4.1 identified a series of bottlenecks and gaps related to DSS. One of these gaps is that growers consider investment costs high to implement the DSS systems correctly. Secondly, it was reported in D4.1 that some of these DSS have to be considered as high-level technologies, requiring a high level of knowledge of the user. D4.3 strived providing a Business Model for one of
these DSS, the IRRIX DSS, to evaluate its potential. It is expected that the format used to evaluate the IRRIX system can be applied to evaluate other DSS.

For the development of the business models, the Business Model Canvas (Figure 1) was used as a basis, a tool that helps to fill in the different building blocks of a business model. For the three cases, the business models were written for the supplier of the technology, but it was clear that also other parties that want to stimulate the use of a technology (Research organisations, Government) can use such a model. Concerning the customer, the business models in this report are written for the end-user, as also for other possible customers (advisors, other equipment suppliers or greenhouse building companies).

The information gathered in the FERTINNOWA project was again crucial for filling in the business models for all three cases. For each business model, the WP4 team closely collaborated with the provider of the technology. The business models represented in this report respect the providers’ point of view and, therefore, the approach for the business models, will differ.

The main general conclusion was that the Canvas model showed a very useful tool for business model development thanks to the structured and systematic set-up. In the defined building blocks the main questions are raised and answered from different points of view but always with strong customer orientation. The three cases have learned that every innovation is asking for its specific approach and that for every case the emphasis is at other things.

The value proposition showed to be the heart of the business model for all three cases, and together with the customer segmentation these blocks were most elaborated. Also, the customer segment was elaborated in more detail. The availability of much information gathered

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1 www. Businessmodelgeneration.com: The Business model Canvas

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in other WP’s of the FERTINNOWA project – as above mentioned – was one of the reasons for this.

There was a strong interaction between the different building blocks: A change in one building block had often effect on several other building blocks, so the development of the business model was a continuous self-developing process, and the content in the blocks of the Canvas Model did change several times. Besides, it was often difficult to distinguish between the different parts of the Canvas model. For example, the channels were often strongly related to the key partners, or more or less the same and also the customer relationships were linked to that, what sometimes resulted in a repetition in the description.

1. Capacative Electro-dyalisis of Water Future

For the elaboration of the business model for the first case, the Capacative Electro-dyalisis (CED), it was difficult to fill in all the blocks already in detail, as the company and the technology are both still in development. The owner of the company left different possibilities open and sometimes the plan for the short term was different than for the long term. The value proposition for the ion-selective CED system was clear, but for Water Future coming up with a total water solution instead of a single technology a sustainable solution for the concentrates is a point of attention. From a technological point of view the geographical applicability was broad. Nevertheless information, based on the FERTINNOWA outcomes from different geographical areas showed that the NW area, and especially the Netherlands, Flanders and the North West part of France are the most interesting customer segments for the short term. The combination of soilless cropping system applying recirculation, the growth of sodium sensitive crops and legislation were important for this decision.

For the short term, different channels and key partners will be used. For creating awareness, different dissemination activities and on site demonstrations were key activities for the short term. As the company has not an extensive network in the horticulture yet, they want to make use of the network of their key partners, like the greenhouse builders and the research stations.

The two blocks related to the evaluation of the business case- the cost structure and the revenue streams – could not be elaborated in this stage. It is clear that this will change the coming period, depending on the role of Water Future.

The value proposition of the second case, the Sodium Removal Unit (SRU) of Optima Agrik, is comparable with that of the CED, as it is also focusing on selective sodium removal. Optima Agrik however, is more focusing at the specific technology itself – as Water Future wanted to sell more a total solution on the long term. Optima Agrik strives for complete reuse of the nutrients and if they succeed the problem of concentrated waste streams is solved. The savings in nutrient cost do cover an important part of the operational costs.

2. Sodium Removal Unit (SRU) from Optima Agrik

North West Europe showed being an interesting market segment. Therefore, OA sought cooperation with water technology supply companies in the Netherlands and Flanders. The SRU requires specific criteria regarding the sodium and chlorine concentration of the treated water and the crops’ nutrient demand. Bearing this in mind, OA opted to set up the business model for
the treatment of recycled drain water. The SRU can as well be applied to treat fresh water, but competition with reversed osmosis proved to be hard. Optima Agrik strives for a personal approach with the customer to investigate the possibilities of the SRU for the farms’ situation and later to develop and fine-tune the installation.

To create awareness, Optima Agrik does not use much social media yet, but the project partners of FERTINNOWA recommend this. Optima Agrik thinks the most powerful channel is the word of mouth and the participation in projects like FERTINNOWA. Optima Agrik considers developing a website in the future.

Most important key activities for the short term are the development of a working prototype and the further on-site demonstration.

3. **IRRIX DSS**

The third case concerns the introduction of Decision Support Systems in the horticulture. The effects of climate changes and the related extreme weather, resulting in stronger variations in temperature, rainfall, water requirements of crops, and the availability of water. A DSS meets the needs for good irrigation management under the changing conditions. This is the added value of the IRRIX automatic irrigation system based at a DSS in combination with a sensors tool in the value proposition besides improvement of the irrigation management, resulting in saving water and fertilizers. Also, the savings in time for the grower were mentioned. However the main customer was the end-user, it can also be used and managed by advisors and supply companies, taking over part of the tasks of the grower, especially for those growers that are not familiar with ICT technologies. So these external parties are also relevant customers. The supplier or installer is the most important contact point between the system and the user. Also the farmer associations play an essential role, facilitating recommendations and control strategies. For some countries, like Spain, the irrigation associations are very important, as they can decide on the needs and availability for water in a certain area.

For the IRRIX-DSS quite a lot of stakeholders were identified as key partners: Local suppliers, irrigation installers, companies selling irrigation programmes, irrigation associations and research institutes, as they can all have an important role in the introduction, sales, installation and use of the system. Demonstration of the system was also mentioned here as a key activity. It is important to have enough and good data available, also of the currently used strategies, to calculate the effect regarding savings and improved growth. The integration of a DSS in automatic irrigation system allows to adjust to the user, not the user adjusts to the system. This was shown to be crucial to support the incorporation of technologies (D4.1 "systems do not fit the user's needs"). The system with soil sensors learns in each irrigation season of the user and the characteristics of the irrigation system to improve its recommendations.
2 Introduction

2.1 Objective

The aim of Work Package 4 is to stimulate transfer of innovative technologies to the horticultural sector, bringing the current state-of-the-art, as benchmarked in FERTINNOWA growers’ survey (D3.3) to the next level. After an inventory of the gaps (task 4.1) and an inventory of innovative technologies (task 4.2), task 4.3 strives to provide a business model for three real innovations. These business models should support both technology suppliers and end-users to close the existing gaps growers applying fertigation are facing in the field of preparation of irrigation water, reduction of emissions to the environment and more efficient use of water and nutrients.

When composing the business models, T4.3, aims to build on the outcomes of the Benchmark survey (D3.3.), Fertigation bible (D3.4), the identification of gaps (D4.1) and the scouted technologies in other sectors (D4.2).

2.2 Activities

For three innovative solutions, a Business Model was developed as an example for other methodologies/technologies. The Business Model Canvas method, described in chapter 3, is used as the basis for the business development within this project, with a strong focus at the customer.

The three key activities are:

a) Customer-Centric Business Model Design with the objective to answer questions like what is the growers’ pain, what does he want to gain from the new technology, how can we best fit to his routines, and what relationship do the growers expect the technology providers to establish with them?

b) Business Model Environment that aims to shed more light on the various markets’ (both sector and geographic areas) key characteristics, that is, present market forces (segments, needs and demands, switching costs), actor forces (value chain actors, stakeholders, incumbent competitors, substitutes), key trends (technology, regulation, societal and cultural trends, socioeconomics) and macroeconomic forces (capital markets, commodities and other resources, economic infrastructure).

The results of the inventory carried out in WP2 and reported in the benchmark report (D3.3) is an important source for filling in those two parts of the Business Model Development.

For three different cases, business models are developed, also with a strong focus at the customer and his environment. The results are described in chapters 4, 5 and 6.

The next cases are selected:

- The Electro-dialyses technology to selectively remove components from water streams, making it (also) possible to close the water cycle
- Sodium Removal Unit (SRU) of Optima Agrik to remove sodium selectively and recover part of the nutrients as a fertiliser
Transfer of INNOvative techniques for sustainable Water use in FERTigated crops

- A Decision Support System (DSS) for irrigation and fertilization recommendations that allow efficient management integrating parameters of soil-plant-climate.

c) **Evaluation of the Business Models** of the three cases, where we look beyond the traditional boundaries defining target markets (in this case growers of fertigated crops) and gain aim for in-depth understanding of potential target markets (e.g. what are our proposition strengths and weaknesses, what opportunities does the technology have and what potential threats does it face?

### 2.2.1 Initiating the Business Model Canvas

The starting point for the business model development was a strong customer orientation, answering questions like what is the grower's pain, what does he expects to gain from the innovations and what relations do the growers prefer in the different stages to introduce and use new technology in his company. For this reason, the Business Model Canvas was used as a tool to fill in the business models for the three cases.

The inventory of the existing knowledge carried out in WP2, with the consultation of over 370 growers increased the insight in the current state of the art in the sector. The results of this survey were further analysed and evaluated, resulting in the deliverable D 3.3 Benchmark Report.

‘The Fertigation Bible’ – as the main output for WP3 – gives a broad overview of the diverse technologies available for all aspects of fertigation in the horticulture sector. In addition to this document, the FERTINNOWA project is developing information in various user-friendly formats (factsheets, practice abstracts, all available at [www.FERTINNOWA.com](http://www.FERTINNOWA.com)) related to all aspects of the fertigation.

To initiate task T4.3, a first concept report was drafted, describing the main general questions about the Business Model Canvas.

### 2.2.2 WP4 workshop:

This draft report was used in a workshop in June 2018 to guide a broad discussion with the different partners of WP 4. During the workshop, a list of cases was made and the technologies to be included in T4.3 were selected. Besides the WP4 members, also, the CEO and a marketing assistant of Water future participated in this workshop. This workshop was organised on the 14th of June 2018 at the facilities of WR.

In the first part of the workshop a general introduction of the Canvas Model was given, followed by a discussion around the main building blocks. The results were added to chapter 3 of this report. Important question within this framework was from which perspective the Business model should be written. As mentioned above, the approach is strongly customer oriented, but the perspective from the technology developer, the technology supplier or, e.g. a governmental organisation can differ, however the main aim, bringing innovative technologies to the grower, will be the same. Another point of attention mentioned was that outcomes could be different for the different regions. In the segmentation part, this will get more attention. Finally, it was
concluded that for most of the building blocks it was not useful to elaborate them in detail at a general level, as for how the completion of these blocks will be very case specific.

The second part of the workshop focussed on two concrete cases. First, an introduction was given on the Electro-dialyses proposition by the supplier of the technology, Water Future, followed by a discussion. Additionally, after an introduction of Fraunhofer, the ePhos® as a possible case was further discussed. The results of these discussions formed the starting point for chapter 4 where the concrete cases were described.

2.2.3 Selection of the 3 cases

Following the workshop, further discussions were carried out to finalise the selection of the 3 cases.

1. Electro-dialyses from SME Water Future (Netherlands): The benchmark survey and the D4.1 report showed that there is a need for technologies to selectively remove sodium from irrigation and/or recycled drain water. The technology of Water Future allows semi-selective removal of sodium. The Dutch SME Water Future was interested in collaborating with FERTINNOWA to investigate the potential of their technology in Europe.

2. Sodium Removal Unit (SRU) from SME Optima Agrik (South- Africa): After further discussions with Fraunhofer and Optima Agrik, it is was decided that the SRU technology of Optima Agrik was a better case to elaborate a business model which would support both the technology supplier (OA) and the end-users at the short term. The exchange of Optima Agrik’s Sodium Removal Unit (SRU) carried out in WP5 had shown that this technology has potential to selectively remove sodium at farms’ sites and allow partly recovery of the adsorbed nutrients (D5.4). The outcomes of the ePhos® exchange showed that the ePhos® would require additional technologies, such as ion exchange to make the ePhos® technology work properly in the new setting (D5.5). The technological readiness level of this combination is expected to be lower compared to this of the SRU (TRL7).

3. The IRRIX Decision Support System (DSS) for irrigation and fertilization recommendations. In recent years, a number of DSS have been developed. The Benchmark survey showed that DSS systems were mainly applied in soil-grown outdoor cropping systems in the Mediterranean region (62% of the respondents) and soilless covered cropping systems, mainly in the North West region (38% of the respondents). Nevertheless, D4.1 identified a series of bottlenecks and gaps related to DSS. One of these gaps is that growers consider investment costs high to implement the DSS systems correctly. Secondly, it was reported in D4.1 that some of these DSS have to be considered as high-level technologies, requiring a high level of knowledge of the user. Within the framework of D4.3, we want to provide a Business Model for one of these DSS to evaluate the potential of the IRRIX DSS. It is expected that the format used to evaluate the IRRIX system can be applied to evaluate other DSS.

2.2.4 Elaborating the Business models

Once the selection procedure was finalised, the 3 business models were prepared in small groups. Each group collaborated closely with the provider of the technology. Conference calls were set up to discuss each of the 9 building blocks of the canvas Model.
3 Business Model Development

3.1 The Business Model Canvas

A business model describes the rationale of how an organisation creates, delivers and captures value in economic, social, cultural or other contexts. The process of business model construction is part of the business strategy (Wikipedia)².

The Business Model Canvas is a tool existing of 9 building blocks that can be helpful for the development of a business model for a company or other organisation. It is a simple model, which can also be used as a decision making tool for the first decisions regarding the business strategy, or it can upgrade an existing investment or improve its efficiency.

The Business Model Canvas, Customer Orientation

As mentioned in the introduction, the focus of the following cases will lay at the customer who is mainly described in the upper part of the Canvas Model. Questions will be answered like

- What is the grower’s pain?
- What will he gain from the new technology?
- What are crucial or critical issues?
- What are the primary stakeholders and key partners?

However, also in the lower part of the Canvas Model, more focusing on financial topics and the business case, the role of the customer, is important and often decisive.

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In the next picture for all the 9 building blocks a number of important questions are given that should be answered for a specific proposition.

![Figure 3 Overview of the building blocks in the business model](image)

For some questions, more general answers can be given for the whole sector and all areas. These will be elaborated in the next paragraphs. However, the answers for most topics differ much from one technology to another and must be filled in more specific per case.

There is a strong relation between the different building blocks of the Business Model Canvas. This also means that if changes are made for one building block, this effects a number of choices in the other building blocks. For instance, if we choose to change the main customer segments, this might also affect the customer relationships, the channels and possibly also the key partners and key activities.

To fill in the Business Models the results of the different activities of the FERTINNOWA project are used. Important sources are the Benchmark Report (D3.3), based at the interviews of 371 growers, the Fertigation Bible (D3.4) and the results of the reports on “Identification of gaps”(D4.1) and “Scouting of innovative technologies” (D4.2), the two first tasks in WP4 ‘Transfer of Innovative technologies to the horticulture sector’.

The important question is from which perspective the Business model is written. In many cases, it starts with the technology provider, who thinks about bringing a new technology to the market, often with economic motives. For them, the lower part of the Canvas model, dealing with the business case is very important. Also, other parties, like researchers, governments and NGO’s can develop a business plan, and for them, other gains (social, environmental,...) might play an
important role. Nevertheless, also for these parties, a sound business case is a must. From the grower’s point of view, the effectiveness of the new investment should be shown in the value proposition. Each technology should impact cost efficiency and customer relations as well.

3.2 Canvas Model for Business model development in Fertigation

3.2.1 Customer Segments

In general, a business model always starts with a definition of the market, the market segments, and the target groups. Within the framework of this project, we will limit to the horticultural sector and within this sector focus on fertigated crops. Nevertheless, the technologies included in this report might have a broader market perspective which can also be considered by the organisation that wants to bring his product to the market. Within the FERTINNOWA project, a distinction has been made on both geographic areas as well as cropping systems. This can be used as a starting point for the segmentation.

A. Geographic area (of Europe)
   - North West
   - Central East
   - Mediterranean

B. Cropping system
   - Soil grown covered
   - Soil grown outdoor
   - Soilless covered
   - Soilless outdoor

Following this approach, already 12 segments can be distinguished. Additionally, the type of crops can increase this number further. Finally, the size of the company can be important about the scale of the product and the economic feasibility.

It is not always necessary to define all the different segments in detail. For some technologies, e.g., technologies related to water storage, the crop type is less important, others, e.g., soilless monitoring systems, are applicable in all areas of Europe. However, about the distribution channels, the location might play a role.

The segmentation as given above is focusing at the end-user as a customer. However, not every technology supplier delivers his product directly to the end-user, but might use an intermediary, like a service provider, a supplier or a consultant. So, additionally, we can define for the different types of end-users one or more market segments of companies who deliver a service or technology to the end-user and for whom this product has added value. However, also for these parties, the information about the end-user is of primary importance.

Finally, as was discussed in the workshop, it is important to know from which perspective the business model is drawn up. In the following, we focus on the technology supplier and end-user. Also, other parties, like a technology developer or a governmental or non-governmental organisation can do this, and these parties can look different at the market and its segments.
In the benchmark report (D 3.3) a lot of information can be found about the current state of the art (implementation rate, awareness) technologies, the growing systems, and crops where fertigation is applied in the different regions in Europe.

Despite that quite a lot of farms (371) are surveyed, extrapolation to a broader population and generalisation cannot be done, but the results give a good idea of the market.

A summary of the main topics for some subjects will be given below, but for more details, we refer to the benchmark report (D3.3).

**Water source management**

For propositions in the area of water source management, it is important to know that, however, in general, ground water is the most applied water source, there are regional differences. In the central East (CE) increasing constrains to the use of groundwater are mentioned. In the North West region, rain water is mentioned as the primary source and in the Mediterranean area, especially in Spain, and in CE irrigation communities often provide the water, so growers have less influence. A minority of the farms uses surface water.

About water shortage, the precipitation differences over the year are mentioned, and storage is important especially in the NW area where a lot of rain water is used. In relation to the storage, algae growth was the main problem mentioned. In the CE and MED region evaporation was also mentioned as an issue.

Mineral quality is an important point of attention, and 32 % of the respondents mentioned this as a problem, especially in recirculation water. Other topics were iron, water hardness, and sanitary problems.

**Water and nutrient use efficiency**

The MED and NW region were more closely aligned in their irrigation and fertigation practices. In soilless crops changes in water and nutrients can have an impact very quickly. The NW region was more concerned with salinity problems, especially in the covered systems. Adding additional water was the most common method to solve the problem. In soil grown crops drip tape was the most used irrigation system, in covered soilless crops drippers and soilless outdoor sprinklers.

For fertigation in the CE region, single fertilizer tanks are most used, in the other regions A/B tanks were most popular.

Decision support systems for estimation of evapotranspiration, water balance calculation, etc. were mostly used in soil grown outdoor cropping systems in the MED region. In general in the MED and NW region tools for monitoring irrigation was much more used than in the CE.

In the NW region, most of the growers registered the nutrient applied (Dutch and Northern French 100 %), in MED and CE this was lower (50 – 65 %).
Transfer of INNOvative techniques for sustainable Water use in FERtigated crops

Effluent Management and minimisation of environmental impact

The level of drain water collection and recirculation differs per region: both are most applied in NW area and less in the CE. It was remarkable that only 40% of the growers recirculated the collected drain water, so still, a lot of this collected water is still discharged. The frequency of drain water discharge differ every day (most in the MED region) to a few times a year or never. In most cases (95%) no treatment was applied before discharge. Drainage water, the water flowing through the soil below the cropping system was collected by about 50% of the growers in the NW area, in the MED region, it was only 3%. Cleaning water from the fertigation systems was also discharged, stored and in the MED region often spread on the land.

3.2.2 Value Proposition

The value proposition is the heart of Business Model Development. What is the need or problem of a customer and how can we satisfy his needs? These needs are more than just a product or technology. It must have added value for the customer. Sometimes the customer is not aware of his needs or does not think that he has a problem indeed.

There are different types of values:

- Financial
  - Lower costs (less raw materials, improved processes, ....)
  - More customers (‘better’ product: product quality, more sustainable, ..)
  - Increase of income
  - Less financial risks
- Obligations
  - Legal
  - Demands of customers (and end-users)
- Social
  - Social/ environmental Image
  - Health of employees
- Environmental
  - Water scarcity
  - Discharge
  - Energy
- Climate change
  - Extreme drought
  - Extreme rainfall
  - Temperature raise

Some values are more quantitative while others are only qualitative. The latter is often harder to make clear but might be more critical. From the FERTINNOWA point of view, there is much emphasis on sustainability, what is at first sight more oriented to environmental topics. However, sustainability also has social and legal aspects and –last but not least – the financial value in terms of lower costs, better process control and higher product quality with added value is of high importance.
The value proposition must not only be discussed for the current status, but also trends have to be taken into account.

The main questions in the value proposition(s) are:
- Which customer needs are we satisfying?
- What value do we deliver to the customer?
- Which one of our customer's problems are we helping to solve?
- What bundles of products and/or services are we offering to each segment?
- What is the minimum viable product?

Concentrating on the needs of the growers of fertigated crops there are some general topics like:
- Saving water addressing the issue of scarcity
- Optimizing the use of fertilizers, improving the growing process, reducing the costs and decrease the discharge to the environment, also complying with the law
- Reducing the use and discharge of crop protecting product

As mentioned above, all these values have a sustainability and a cost component. For a clear explanation of the value, comparison with alternative technologies is often constructive.

In paragraph 3.2.1 we distinguished two types of markets: the end-user and possible intermediates, like equipment suppliers and service providers. However for the latter, the added value for the end-user is essential, there might be other values for these companies, like offering a better (total) package, improving their own system to a more integrated sustainable solution.

During the workshop it was concluded that the value proposition is rather specific depending on the product we want to bring to the market, so it is of no use to further elaborate this on a general level.

It was also mentioned that especially for the value proposition, the relation with the segmentation is of main importance, as, e.g. values concerning costs and legislation can differ strongly per region and crop type.

### 3.2.3 Channels

In this part of the business model, the main question is which channels we use to reach the target groups. This concerns the complete process from orientation, sales, delivery and after sales. Also, the logistics (package, transport, disclosure) are part of this.

The questions to be answered are:
- Through which channels can we reach our customers?
- How do other companies reach their customers?
- Which channel works the best and what are the most cost-effective?
- How can we integrate them with customer routine?

These questions must be answered for the next parts of the business process:
Orientation/Awareness:
During the interviews and other contacts with potential customers, awareness was shown as one of the most important questions. For example, growers were asked to rate the sustainability of their water use.

The majority of respondents considered their water use to be “sustainable” or “very sustainable”. This was particularly the case especially in the CE region where 73% of respondents considered their water supply as “very sustainable,” but the same tendency was observed in almost all countries.

A lot of potential customers do not know the new technologies or do not think this is relevant or applicable in their situation. Additionally, the customer is often not able to compare the innovation with other (existing) technologies.

Growers often use external advice by commercial advisors, private consultants, governmental extension services (more in CE) and cooperative advisors (more in MED).

General information about the innovation can be given via technical and professional journals. Besides a general technical description, practical examples are very important — the same counts for presentations at congresses and workshops. For buyers, the expertise in practice is of main importance. The different dissemination routes that are used in FERTINNOWA can also be very useful channels. The Fertigation Bible gives a lot of technical information and also says something about the practical use. Also, the deliverables D4.1 and D4.2 with their focus on bottlenecks and Innovations are important sources. However, most important are the pilot projects on new technologies, where the technologies are tested for a longer period. Within the FERTINNOWA project, the showcases also fulfill this role, and the support of independent researchers in these showcases can help to decide.

In general, it is clear that knowledge transfer and dissemination activities — as they also play a major role in European projects - are a very important channel for orientation and awareness.

Offer and sales
The main question within this framework is via which channel we offer the value proposition to the customer. Do we offer the technology direct to the customer or via an intermediary? This can be a company who is already a supplier of equipment for the sector or a company that supplies comparable systems in a particular area, e.g., in water treatment or monitoring. In that case, we have two types of customers: the end-user and the company to whom we want to sell our product.

It is also possible that our product is only part of a solution or that we deliver only one component, e.g., a membrane module of a water treatment system. In most of the cases, the offer and sales use the same channels, but this is not necessary.
Additional services

Delivery (conditions), Payment, Guarantee, Starting up, Support, after sales can be mentioned in this framework. It is for example necessary that some advisors or technicians use this technology to generate crop management information. The farmer cannot make mistakes when buying a technology that he will have to amortize over a long period. Solutions as consultants that acquire this technology to give a service to the client and also to get well the technology can acquire the technology that best suits the needs of all its customers.

The two latter are in general more internal topics and will not be further elaborated.

3.2.4 Customer Relation

Important questions within this framework are:
- What kind of relation is important for the customer?
- How to build this relation?
- Who should maintain this relation
- What can we use (trust, ..)?

The kind of relation with the customer depends on the technology and channels we use and can differ from stages of contact. These stages are starting from the moment that we are trying to get the interest of the customer, the moment of purchase and even after the sale to maintain the relation. Important know is whether the customer prefers a more familiar and/or personal relation or more business-like or anonymous relation.

In the first stage of a relation it is important that there is trust and believes. Other customers, for instance, growers who know the potential customer, can be helpful in this stage. He can help with building this relation and might also know what kind of relation he prefers.

There are different ways to start a relation with a customer. The first one is via digital platforms such as mail and social media. A more personal way to obtain new customers or to maintain existing relationships is via telephone or sector events.

The relation can start via mail or other social media, but also via sector events, congresses, but also more personal through a telephone call or a visit at the location.

There are different persons in (and outside) the company who can work on this relation, also depending on the stage of the contact. The sales and/or account manager is often the first persons who start the contact. However, this can also be the technician, who has more knowledge about the technology. In this stage, it is important to know who is the contact at the customer side, what is his position and what are his competences. The role of the technician will be important to build trust. It can also be important to make a clear distinction between a more business-like contact and the technical persons.

Maintaining the contact can be done at different levels, at management level, at a technical level, by (after sales) services and maintenance.
3.2.5 Key partners
Which partners we need to make our business successful depends strongly on the topics mentioned above and the stage we are. What is our real product in relation to the value proposition, who are our customers (segments) via which channels we want to work and how we are going to build and maintain the relation?

For building the relation with the customer and create awareness we need another type of partners who already have a relation (advisors, governmental organisations, suppliers of other systems).
For making the product, we need suppliers of materials and resources, etc. Maybe we do not want to build the equipment ourselves, so we need a partner to do this. When we want to use different channels for bringing the product to the customer also partners are needed. Moreover, last but not least we might need financial partners, who are willing to share the risks or be helpful to raise funds, especially in the case of a start-up. Which partners this should be is very specific to the case.

The next two topics will not be elaborated at a general level, but only filled for the specific cases.

3.2.6 Key activities
What are the main activities/actions are needed to. Examples are
  - Set up laboratory/testing facilities
  - Apply for a Patents
  - Make Standard Contracts
  - Service

3.2.7 Key Resources
A long list can be made:
  - Financial and legal means:
    - Loans, subsidies, co-investors, ...
    - Contracts, Assurances
    - Patents
  - Operational means
    - For production
    - For transport
    - For testing (laboratory facilities
    - Building, offices, laboratory, meeting rooms, parking
    - Raw materials, Water, electricity, ...
  - Human resources
    - Production
    - sales
    - Knowledge (technical, finance, legal, market

Further elaboration of these issues will be done in the cases.

The next points are important for the business case and will not be elaborated here too. They are strongly related to the business case.
3.2.8 Cost structure

Important is to have a good view of what is the customer willing to pay about the value proposition. On the one side, we have the organisation driven by a maximal cost-reduction on the other side the maximum quality driven organisation. Most organisations are somewhere between. Important is to have a good insight into the different costs.

General topics to be considered are:
- Relation Fixed and variable costs
- Non-recurring and recurring costs
- Economy of scale
- ...

More specific costs that can be mentioned are:
- Costs of finance
- Rent
- Materials, Components, raw materials, etc
- Water, electricity
- Labour
- Etc.

Which key resources and activities are most expensive? Are there any costs that can be reduced in the future or by the implementation of a new way of working.

3.2.9 Revenue streams

The revenue streams can also be written out of 2 perspectives. The first one is for the growers; the second perspective is out of the technology supplier. In this report it will be written from the technology supplier it’s the point of view with a focus on the consumer.

Out of the supplier’s point of view, we have the following questions raising:
- For what value are our customers willing to pay?
- What do they currently pay?

What is the revenue model:
- Sell a product or service
- Sell a complete installation or a component
- Buy vs. lease
- Support financing
- Additional revenues (membranes, .. spare parts, ..., licences)
- Services, (Design, Build, Operate)
4 Business Model Cases

4.1 Business Model for the Capacitive Electro-dialysis (CED) system of Water Future

The first business case as described in this chapter concerns the CED desalination system in the setup as designed by Water Future. This young Dutch SME originated as a spin-off company from Fuji. At the moment of writing this report, the technology is still under development as is the company, so the development of this business model within this FERTINNOWA project is the first step. In the business models, part of FERTINNOWA the technology will be explained and written in a way that it contains much information for growers. For now, the technology still needs to be developed further and needs further testing and demonstration.

4.1.1 Value proposition

Water Future’s ion-selective desalination system makes use of selectively permeable membranes to separate salt ions or selective ions dissolved in water to obtain sweet water suitable for reuse for irrigation or as potable water. The technology desalinates water by transferring ions and some charged organics through a paired anion-and-cation exchange membrane under the driving force of a direct electrical current. The physical principle used is called electro-dialyses (ED). In Annex 1 the working principle is described in more detail.

The technology is adapted for application in greenhouse horticulture to semi-selectively separate the monovalent ions such as sodium, potassium, and chloride from the valuable multivalent ions such as calcium, magnesium and phosphate. The ED technology uses a membrane stack with monovalent selective membranes.

Besides the electro-dialysis stack, a complete CED system consists of a coarse filter, a membrane filter, a carbon filter for the prevention of fouling and a UV unit for disinfection. These technologies are often necessary as pre-treatment for the ED, but carbon filtration and disinfection can also have a function in the whole treatment of the water. Also, the above mentioned ED Reversal option, making it possible to switch the polarity of the electrodes is applied to prevent fouling. Additionally, remote control is part of the system.

At first, the system is developed for small scale applications (1 - 10 m³/day) As the membrane system has a modular set-up, upscaling is rather easy by increasing the membrane area (e.g., the number of membrane modules).

Costs:

A first cost-estimate is made for a system that can cover up an area of up to 2 Ha, having a drain water capacity of 2,5 m³/ day (750 m³/year).
The expected investment costs for a small ED system are estimated around €30.000. The energy costs are estimated at 0,5 kWh/m³. The expected lifespan of the membrane is 2-5 years. After this period, the membranes should be replaced to guarantee the operation of the system.

A first estimate of the operational costs per year for a system of 2,5m³/day with 10 months or 300 days per year of active use of the CED is given below:

- Electricity (max 0,5 kWh/m³): € 75
- Replacement membranes: (2 years): € 800
- Maintenance (2 %): € 600
- Total € 1.475 / year

Based on the costs given above and a capacity of 750 m³ per year we can conclude that the operational costs are about €2/m³. The yearly depreciation, with a depreciation time of 10 years is € 3.000.

These costs do not include the costs to remove the produced waste stream neither costs related to the pre-treatments (coarse filter, activated charcoal, ...).

Revenues:

The CED technology leads to the (partly selective) removal of sodium. As a consequence, water reuse is possible what leads to savings in nutrients and water costs.

- For nutrients, the savings are estimated at € 1.200/ha.
- The savings in water costs are depending on the water price and are estimated at € 500 - € 1.000 per year (for Dutch circumstances).

Other savings, also depending on the local situation, are amongst others the reduction of the volume of the saline drain water that should be discharged (reduction of 95 % possible) and the re-use of plant protection products (PPP), that reduces the need of treatment not or very limited. Finally, maintaining a constant water quality of the recycled stream might affect the product quality and the yield (see also below).

Electro-dialysis applications in the fertigated sector

For all crops and cropping systems, it is essential to maintain an acceptable quality of irrigation water with regards to salinity and the composition of chemical elements and compounds. In addition to crop species, the type of cropping system influences the required water quality. For soilless growing systems with recirculation of drainage, the requirements for the quality of irrigation water, regarding salinity, sodium (Na) and Chlorine (Cl), are high in order to ensure that the accumulation of these components during recirculation commences from relatively low base values.

Where groundwater is used, commonly, the salinity and chemical composition are issues that have to be taken into consideration for decisions related to crop selection. Additionally, the water may require treatment before being suitable for irrigation. These issues are particularly important in drier Mediterranean regions where groundwater, with higher salt content, is commonly used. In some Mediterranean regions, an on-going increase in the salinity of groundwater is occurring which may progressively increase the requirement for the treatment

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of irrigation water. Water treatment is likely to increasingly become an essential technology to solve the issue of salinity of irrigation water. This issue is important for soil-grown crops in these regions and will be of particular interest for free-draining soilless cropping that, in the future, may be required to implement recirculation.

The issues on water in Northern European greenhouses is different. Around 2013, Dutch and Flemish studies showed that between 0-10% of the drain water was not recirculated but instead discharged. Accumulation of the sodium concentration by recirculation was listed as the main trigger for discharge (Beerling et al., 2013, Berckmoes et al., 2013). Figure 5 gives an overview of the sodium in- and outputs in a closed growing system. The figure shows that sodium input origins from the applied water source, fertilisers, plant protection products, drain water treatment. Sodium also can be passively added to the recirculation system through root exudates and pathogens. As sodium is a micronutrient, the uptake of this element through the plant is only limited. Once the concentration of sodium exceeds specific threshold values, plant growth inhibition and quality losses might occur [WR, 2012³].

Figure 5 Sodium in- and outputs in a recirculation system

Within the framework of the European Water Framework Directive (WFD) (Directive 2000/60/EC) and dependant of the situation on water quality in the EU Member States, discharge of the nutrient containing drain water needs to comply with specific regulations. The implementation of the WFD might differ for each EU member State. In Flanders, for example, discharged drain water can i) be spread on covered land when specific guidelines are met or ii) be removed by an acknowledged processor. In the Netherlands, drain water can be discharged on the sewage system in case a certified water treatment installation is used. The certification

³ Maas, B van der; Meijer, R; Driever, S; Warmenhoven, M; Boer, P de; Blok, C; Marrewijk, I; Holtman W; Oppedijk B (2012). Opsporen en meten van groeiremming vanuit het recirculatiewater. Werkpakket 2. Wageningen UR Rapport GTB-1200
requires that the technology removes at least 95% of the plant protection residues under standard testing conditions. Also, specific guidelines are set regarding the discharge of nitrogen and phosphorus. By 2027, Dutch greenhouse growers will have to comply with a near “zero discharge” policy.

In Belgium and the Netherlands, there is a general tendency to improve recirculation processes even more and reduce the discharged volumes as removal or treatment of these streams are or are expected to be costly.

**Perspectives of the Water Future semi-selective desalination technology in the fertigated sector**

In task 4.1 of FERTINNOWA, the main bottlenecks and gaps for sustainable water use are identified as well as the related needs.

To support the further increase of the recirculation rates, there is a general need for:

- Technologies with higher selectivity towards unwanted salts as sodium and chloride, not removing valuable nutrients
- Technologies that produce no or only limited waste, known as zero liquid discharge processes (ZLD). Most of the desalination technologies are concentrating technologies, producing a concentrated brine. Discharge of these brines is more and more a problem.
- Technologies with minimal risk of (membrane) fouling:
- Low cost technologies for nutrient removal:

Selective removal of elements, such as sodium, has a broad potential field of application in different production steps of fertigated cropping systems (see also annex 2):

1. For the removal of sodium from the supply of irrigation water (5,000-10,000 m³/ha?)
2. For closing the water cycle in recirculating systems (assumed a 30% drain surplus, app. 30% is 1500 – 3000 m³/ha/year)
3. For treating water before discharge, originally not to be reused and with ED treatment suited for re-use. (assumed 5% of the supply water).

**Ad. 1. Electro-dialysis for desalination of irrigation water (water supply)**

Surface and groundwater are still frequently applied in the horticultural sector. Both sources tend to increase in salinity, particularly in the Mediterranean areas, but also in North Western Europe.

The FERTINNOWA benchmark survey showed that higher electro conductivity values (mainly due to higher salt contents) were reported as a problem in Spain, Poland, and at farms where recirculation was applied (mainly north-West European farms). Reverse osmosis (RO) was the most common used technology to treat raw water streams at farm scale. Those respondents were mainly located in the Netherlands, and they installed the system due to the poor quality of the brackish ground water.

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4 [http://edepot.wur.nl/334474](http://edepot.wur.nl/334474)
Mediterranean correspondents reported not to apply on site treatment of the water. In case the water was provided through an irrigators community, the water was already desalinated by the irrigators community, in many cases as well by applying large reversed osmosis installations.

For the production of irrigation water from different sources, ED has to compete with other technologies like RO as the state of the art desalination technology. Related to RO, some disadvantages have to be reported:

1. Non-selective method: all ions are removed, as well the valuable ions.
2. Membrane fouling issues leading to performance loss and the need for chemical cleaning.

Ad. 2. ED for closing the water cycle

According to the benchmark report, accumulation of ions by recirculation of closed water systems is the main issue faced by growers who recycle drain water (Figure 6). When recycling the drainage water in soilless systems, accumulation of monovalent ions like sodium and chloride is possible.

With ED it is possible to remove these monovalent ions selectively. Polyvalent ions and as well other molecules, such as crop protection agents, remain in the nutrient solution and will be reused. The disadvantage of ED is that also valuable monovalent nutrients like Potassium (K+) and Nitrate (NO3-) are also partly removed and have to be added.

The use of an ED system in recycling the drain water and closing the water cycle can lead to more constant water quality and better control of the growing system. Research is ongoing to develop selective sodium membranes which could make the system more selective so no loss of potassium and nitrate occurs.
Ad.3. **ED for treating the water before discharge**

By ED it is possible to reduce the concentration of all ions in the waste water to the limits for discharge. Besides this “clean” water also a concentrate is produced that has to be discarded or in some cases can be reused in salt tolerant use cases, for example in irrigation of grass meadows with cattle. In many applications, the clean water can be re-used. In that case, this option is comparable with the second option for closing the water cycle but might differ in the time frame, when there is not continuous treatment and re-use and in the concentration of the water to be treated. For the treatment of discharge water, an additional removal technology of the ppp’s and the multivalent ions (phosphates) is in most cases necessary unless the treated water is reused.

It is possible to selectively remove monovalent ions, but it is not possible yet to make a separation between these ions e.g., to selectively remove sodium and not potassium and nitrate. Research is ongoing on this area.

In the NW area, especially in the Netherlands, ED looks most promising in the second application, closing the water cycle. In this application the technology tackles three of the main problems in relation to water:

1. Prevention of the discharge of nutrients and ppp’s to the environment.
2. Reduced use of water and nutrients due to increased recirculation.
3. Reduction of water and nutrients usage leading to costs savings.

In the next section, this will be further discussed, also taking into account the differences between the different areas in Europe and the crops and cropping systems.
**Elektro-dialysis compared to alternative technologies**

Within the framework of the FERTINNOWA project, a reference document was composed on the state-of-the-art technologies related to fertigation. In this reference document, entitled “the Fertigation Bible,” a broad overview is given of the main alternative technologies for desalination. A summary of the technologies most competing with ED is given in Annex 3. More detailed information can be found in chapter 3 of the *Fertigation Bible*: Optimising water quality – Chemical composition.

Most of the alternative technologies for desalination mentioned in the table are membrane technologies, having some common issues:

- Fouling of the membranes
- Low or no selectivity between monovalent and multivalent salts
- Production of concentrates to be discharged

Reverse osmosis is the most proven desalination technology in this application, especially in the preparation of irrigation water. As a high pressure is needed it is, in general, more vulnerable for fouling than ED and is non-selective between monovalent and multivalent salts, retaining almost complete all salts. Nanofiltration is also a pressure driven technology and has, because of a lower pressure demand, a lower fouling tendency. Some selectivity in NF is possible between monovalent and multivalent ions. This can also be a dis-advantage in the case of water re-use, as the monovalent ions, so also Na and Cl stay in the water treated, and the other nutrients are concentrated and removed. Also, Membrane Distillation is vulnerable to fouling and not selective; advantage is that the technology can also be used for simultaneous disinfection. The Capacitive Deionisation (CDI) technology can also have problems with fouling of the electrodes. By using selective membranes, some selectivity is possible. The technology looks most efficient for low salinity waters.

For all membrane technologies, a good pre-treatment is needed to prevent fouling. Additionally, all these technologies have the problem of delivering a concentrate. Forward osmosis can be used in combination with these technologies to further concentrate the brines. (Modified) Ion Exchange (IX, MIX) is the only technology mentioned that does not use membranes. It has a lower fouling potential. The possible re-use of the regenerate decreases the problem of concentrates. Modified Ion Exchange is the second case for the Business Model development, so a more detailed description of this technology is given in section 4.2.

Forward Osmosis (FO) can be used to withdraw water from already concentrated streams. A high concentrated draw solution like liquid fertiliser is used and diluted. This draw solution can then be reused as a nutrient solution.

**Discussion:** In comparison with these technologies, ED is, in general, less susceptible to fouling, and efficient in energy use for separation. ED is more selective than the other membrane technologies since only charged particles/ions are attracted and removed from the stream to be treated. The selective removal of mono-valent ions is possible, but it is not possible yet to make a separation between these mono-valent ions e.g., to remove sodium and not potassium selectively. Research is ongoing in this area.
Transfer of INNOvative techniques for sustainable Water use in FERTigated crops

If the specific advantages of ED are not relevant, e.g. for the desalination of surface water and discharging brines, RO currently has a competitive advantage. RO is a proven technology, applied for a very long period and widely used in agriculture. The costs of the RO systems and the membranes are relatively low.

Within the framework of value proposition it is also relevant to know how the competitor sees our product? What is the advantage of the product in comparison with his product?

4.1.1.1 Value proposition: Summary

CED is a competitive desalination technology for the treatment of water in fertigation. It saves water and nutrients and prevents the accumulation of monovalent ions. By application in closed water systems also plant protecting products will be recycled and kept in the water system and do not have to be discharged via the drain-water. Besides the efficient use of water, nutrients and PPP’s it results in better control of the water system, more constant water quality, and possibly improved growth.

The added value of ED is more specific:

- The semi-selectively removal of salts from other components separation is possible between monovalent and multivalent ions by use of ion-selective membranes. Selectivity between Na and K+ and NO3- is not possible yet, but is expected in the future. By exchange the membranes the installation can be simply adapted in the future
- ED makes it possible to close the water and nutrient cycle, saving water (up to 90 %) and multivalent nutrients (80-90 %)and other resources
- Decrease or avoid the need for end-of-pipe treatment for the crop protecting products (incidental purges can be solved by jobber/mobile installation)
- Decreases the amount/ volume of waste in comparison with other desalination techniques. The concentrate is a solution only containing mono-valent ions (depending on region there can be specific requirements to upgrade or process to Zero Liquid Discharge)
- A better and more constant irrigation water quality and possible better crop growth
4.1.2 Customer segments

4.1.2.1 General

Desalination and water re-use is a topic that is relevant in a lot of sectors not only in horticulture but also outside the agriculture, so CED has broad field of application.

This business-plan, however, is restricted to the horticulture and particular to the fertigation sector. More specific to growers with already (semi)-closed water systems having issues with salt accumulation (combination of water quality vs. crop tolerance on salts).

As mentioned in chapter 3 it is very important to realise for whom we are writing the business plan. For the technology supplier who wants to do business and who wants his technology to be implemented, the national or European government who wants to bring the innovative technology to the sector or the research institute or from the customers perspective who wants to use the technology. This business model is primarily drawn up from the supplier side, in this specific case for Water Future where the CED system has been developed and that wants to bring the technology to the market. The Canvas Model is Customer Centric based. Herein the end-user is the most important customer. It is of primary importance that he is going to apply the technology. Further segmentation of this customer is needed.

Depending on the channels (see 4.1.4) we want to use to bring the CED technology to the market another type of customers can be defined, like:

- Suppliers of technology in the horticulture
- Service providers
- Advisors

Water Future, however, wants to focus on the end-users and regards the above mentioned parties as key partners.

4.1.2.2 The ED end-users segments

In chapter 3, the fertigation sector is divided by geographical area, cropping system, and cropping types. For these segments we have to answer questions like:

- For whom are we creating real value
- Who are the most important customers
- What are the customer’s archetypes

Based on the value proposition, we should focus on customers who are interested in the closure of the water-cycle, efficient use of water and nutrients and limit the environmental impact. Additionally, growers who have water sources with an increasing salt content are possibly another interesting segment.
Geographical area.

A far going closure of the water-cycle looks most interesting in areas of water scarcity. Although it is expected that this is the main problem in the southern area of Europe, according to the Benchmark Report it was more frequently reported by farmers from the NW region.

Scale:
For the Dutch situation an overview has been made of the number of greenhouse companies about the size of the company, see table 2. No distinction has been made between soil and substrate growing systems.

<table>
<thead>
<tr>
<th>Size of the company (area)</th>
<th>Number of companies</th>
<th>Moderate discharge (m³/week)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 0,25 ha</td>
<td>1073</td>
<td>1,6</td>
</tr>
<tr>
<td>0,25- 1,5 ha</td>
<td>1906</td>
<td>12,4</td>
</tr>
<tr>
<td>1,5- 3 ha</td>
<td>865</td>
<td>33,6</td>
</tr>
<tr>
<td>3-5 ha</td>
<td>469</td>
<td>60,8</td>
</tr>
<tr>
<td>&gt; 5 ha</td>
<td>483</td>
<td>155</td>
</tr>
<tr>
<td>Totaal</td>
<td>4796</td>
<td>32,9</td>
</tr>
</tbody>
</table>

Most of the companies in the Netherlands are forced to choose the treatment of their drain water because of the reduction of PPP emissions. For these companies, the closure of the water cycle is a good alternative as this can reduce the need for this treatment and also recovers nutrients and water (see 4.1.2). Especially the companies between 0,25 and 3 ha, in total almost 3.000 companies, is an interesting market for CED. However CED is applicable at different scales and – as it is a modular system – it can be relatively easily scaled up.

Due to saving measures, the volume of water to be discharged by the companies will decrease the coming years (Ruijven et al., 2017). A translation towards Europe is hard to make, both about the number of companies and to the need to remove both nutrients and crop protecting products.

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According to EU statistics, data\(^6\) in whole Europe are almost 920,000 holdings who grow fresh vegetables, which is 12.4% of all European farms with an arable area. Nearly half of those are in just three countries: Romania (22.1%), Poland (15.4%) and Spain (11.9%), see also figure 8.

\[\text{EU-28} \]
920 thousands holdings

- **Romania**: 22.1%
- **Poland**: 15.4%
- **Spain**: 11.9%
- **Bulgaria**: 7.0%
- **Italy**: 8.7%
- **Other 22 MS**: 24.4%
- **Lithuania**: 10.5%

![Figure 8 Distribution of growers of fresh vegetables in Europe](image)

The United Kingdom and the Netherlands devote the highest average property for growing vegetable (17.4 ha in the UK and 10.3 ha in the Netherlands). 14% of EU farmers grow vegetable on less than 1 ha, which is 79.5% of all holdings, cultivating vegetables. 7.2% of all fresh European vegetables are grown under glass or another cover, within this, the share is much higher in Spain (17.2%) and Italy (13.3%). The fresh vegetable is grown on almost 2.2 million hectares in the EU, near half of it in Italy, Spain, and Poland.

To what extent these companies are interested in CED depends on some factors in relation to the value proposition: Water savings, nutrient saving, need to remove ppp’s, costs and will differ from one region to another.

In the CE and East European countries, a lot of small companies exist, but soilless recirculation systems are only limited applied. For the Med area, the demand for sodium removal in closed systems is also hardly relevant since only very few growers use recirculating soilless systems. If we consider water supply for irrigation, sodium is a problem as EC is, so other ions are then also involved. This explains the high desalination infrastructures being built in the med area and the search for alternative water sources. To summarise, there is at the moment no regulatory demand for sodium removal from drainage water and there and neither there is a demand from

---

\(^6\)https://ec.europa.eu/eurostat/statistics-explained/index.php?title=The_fruit_and_vegetable_sector_in_the_EU_-_a_statistical_overview

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 689687
Transfer of INNOvative techniques for sustainable Water use in FERTigated crops

the production sector. If in the future this demand may arise, then RO would probably be the adopted and most preferred technology.

There is also no regulatory demand in the Mediterranean area to reduce sodium contents in the effluents from soilless systems. It is true that in some aquifer systems the increase of EC due to agriculture emissions is straight and leads growers to exploit deeper aquifers, with the concomitant sustainability problems since these are also fossil water sources. At the moment RO is considered as the only feasible alternative, but in future also CED can be applied.

**Cropping types**

The need to remove sodium differs by crop. Desalination in closed systems is especially important for crops vulnerable to high salt concentration, like strawberries, lettuce and sweet pepper. Tomato crops have a higher salt tolerance.

<table>
<thead>
<tr>
<th>Cropping type</th>
<th>NW Europe</th>
<th>Central East Europe</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Small</td>
<td>Med</td>
</tr>
<tr>
<td>High salt sensitive crops: Sweet pepper, Cucumber, Strawberry, Ornamental plant</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Medium salt sensitive: Tomato’s</td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>

Based on the table above, Water Future decided to focus primary at the NW area, looking at crop systems with a low sodium tolerance, like strawberries and sweet pepper.

**4.1.2.3 Other segments**

In the introduction, besides the end-user, also, other customers are mentioned. Depending on the market segment it might be useful to make use of other channels to bring the product to the market:

- Greenhouse builders
- Builders of fertigation systems
- Service providers
- Advisors

In the Netherlands, the growers make use of all the channels.

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7 The salinity in this part of EU is in general not such big problem. E.g. The irrigation water in Slovenia content 2-9 mg/l Na+, what is more or less the consequence of mineral consistent of geological background (the limit is 200)
Growers who want to invest in a new water system prefer to buy a complete system, so greenhouse builders and builders of water systems are also an important segment for the technology supplier.

However, water is very important for growers, water treatment is often not regarded as the core business. They prefer that a service provider or advisor unburdens them for water supply and treatment. In Eastern Europe, a technology supplier and advisory services often work together in order to organize technological days with a presentation of equipment or technologies.

It can be concluded that in the Netherlands all the mentioned segments are important for the supplier.

4.1.3 Customer relationships

What kind of relationship does the customer in the different segments prefer? And, who has to maintain the contact? There are several options, depending on the product and the way it is brought to the customer. For CED different routes can be used.

In the situation an installation is directly sold to the end-user it is important that the contact between the operator and the supplier is very close, so that in the case of dysfunction the customer immediately contacts the supplier. Especially in the case of an innovation like CED it is important that problems are solved at the short term to prevent that the technology is written off. But a good contact is also useful to have a good after sales contact, that will be maintained for a more extended period. For the ED supplier, this contact can be very useful to promote his technology, showing results in practice.

For most growing companies, water is not their core business. However, it is an essential part of the production process. Service providers for water technology solutions can provide water services to industrial clients, using its knowledge of technology and the market, as well as its experience and financial capacity on the basis of Design, Build, Finance, and Operate (DBFO) contracts. This means that growers can focus on their own core business and pay per m3 of water delivered, while the service provider is fully responsible for the water supply. For this model the relationship should be based on trust and – especially in small companies- direct contact with the customer is very important.

Water Future will also act as a service provider at the long term, not only delivering technology, but a complete service for the water system.

The culture of a region/country has also effect on this. In the Mediterranean area, but also in CE Personal assistance from reliable advisors is very important for the growers. They don’t trust too much information coming from the academicals or universities. Some extension services provided very useful information with a very good record of compromise with the sector in terms of technical guidance and knowledge. During the last decades public extension services have been dismantled, so private services have taken over with their commercial interests.
4.1.4 Channels

In this part of the business model, the question is answered which channels we use to reach the target groups in the different parts of the process from orientation, sales, delivery after sales, also including the logistics (package, transport, disclosure) and services.

Channels for Orientation/ Awareness:

ED is an unknown technology in fertigation. To inform the potential customers about the existence and performance of this technology, different channels can be used from technical and professional journals and congresses to direct contact and demonstration.

However, to convince end-users in the horticultural sector about the applicability and advantages of the technology it is essential to show them practical examples of applications comparable with their situation. The presentation of these results can be done at congresses and workshops preferable by – in their mind – independent reliable persons, like the end-users where a test have been carried out or a practical researcher of an agricultural research institute.

Also, showcase events, like they have been organised in FERTINNOWA and other dissemination activities specific for this sector are important channels for orientation and awareness. The deliverables D 4.1 and D4.2 on bottlenecks and innovations are important sources of information for the customers.

For ED the next activities are proposed:
- Presentations at sector meetings and congresses. This channel is used to provide further publicity to the technology and make the future customer more familiar with the applications. These presentations should strongly focus on the application of ED in practice (see also next point) and the comparison with existing solutions. Presentation by the end-user is a big advantage.
- Demonstration and showcases. Probably this is for the horticulture sector the most important channel. Growers often think that their situation is different from other sectors, so it is important to show in a pilot or (small scale) demonstration the practical applicability. To give growers the opportunity to visit the demonstration installations and discuss the results with the local grower gives an extra dimension to this. Research station can play an important role here. Co-creation of the solution, which is the most appropriate for a dedicated farm.
- Publication in technical (sector) magazines.
  Also here the focus should be on the practical application and not on the promotion of the technology itself. Examples: Hortidaily,...

Besides the technical performance, it is also important to show the advantages for the long term in relation to national and international policy on sustainable fertigation where possible governmental and non-governmental parties can be a useful channel.

Especially in Central Eastern and the Mediterranean region, governments are supporting companies and cooperatives for the acquisition of technology for efficiency in irrigation and fertilization of crops. Although in many cases the lack of information and the lack of commercial scruples make it possible to acquire a technology that is not adapted to the users. The
technological centres are doing work in the adaptation of this technology and its application in agricultural works. Field trials in commercial parcels are facilitating the integration of technology.

**Offer and sales**

The main question within this framework is: do we offer the technology direct to the end user or via an intermediary (see also 4.2 segments). This can be a company who is already a supplier of equipment for the sector or a company that supplies comparable systems in a particular area. For ED both channels can be used.

Closing the water-cycle is an interesting total concept that can be part of the total water system that can be offered by an equipment supplier or service provider. So companies in this area are an interesting channel, especially in the situation that new installation is built, or existing water systems must be adapted.

But in many cases, the system can also be directly sold to the end-user. In that case, an additional service can be offered to optimise their water-system.

**Additional services**

For all the other services, such as delivery (conditions), payment, guarantee, starting up, support, after sales, the channels to be used are internal topics of Water Future, not elaborated yet. For the successful introduction of ED in fertigated growth it is proposed to limit to not too complex applications in this segment and stay directly involved in the introduction at a company, also when we choose for intermediates that deliver the product to the end-user. The use of subcontractors for specific services is a good option is.

4.1.5 **Key partners**

For bringing the ED technology to the market many partners play an important role:

- **Engineering and building company.**
  During the first tests and the introduction of the CED in the market, this activity will be carried out by the supplier itself. When the production of the systems are scaled up, external engineering and possibly building companies should be involved

- **Supplier (OEM) of spare parts and other components (pumps, valves, membranes, electrodes, .....)**
  For the production but also for delivering good (maintaining) services to the customer, it is important that components and spare parts are available in time.

- **Research institutes and stations for development, tests and technical support.**
  Research institutes are needed for the further development of the systems and help with trouble shooting. They do have the possibilities to test the systems at a (semi) – practical scale. Finally, as already mentioned in 4.2.4, in general, they do have good contacts with (possible future) customers Names of important institutes are: Wetsus, WR,...

- **Financial partners?**
- **Possible Joint ventures?**
- **Government and NGO’s?**
- **Transport companies: ship, plane, truck**
In all cases, a partnership should express a win-win situation. The financing should also offer a win-win situation, e.g., testing centres should care for the next customers by networking, raising awareness and by publishing project outcomes about it. This is usually offered in the contract with each of them.

Cooperation with governmental and non-governmental organisations is useful in the promotion of ED technologies as a sustainable solution for legal or social topics. Besides for raising funds, this cooperation can also be helpful. In the south of Spain, different government organizations make a great effort to provide technology and the development of start up in agriculture. Key resources.

4.1.6 Key activities

What are the key-activities to offer our value proposition to the customer? This block is very close related to some other blocks, like channels, key resources, and customer relations.

Examples are (from chapter 3):
- Dissemination and promotion activities
- Contact with key partners for R&D, marketing promotion, etc.
- Collecting market data (also using customer interviews and surveys of FERTINNOWA
- Organise financial legal, administrative topics
- Set up laboratory/testing facilities, including pilots and demo’s
- Design/ Building prototype and testing
- Set up a production facility
- Start series production
- Apply for a Patents/ patent search
- Make Standard Contracts
- Sales support and services

For Water Future at the short term the main activities are related to the development of a prototype, the different dissemination and promotion activities, including demonstration and showcases.

4.1.7 Key resources

This part has been elaborated in a confidential Business plan of Water Future. Water Future preferred not to implement this information in this report.

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http://www.juntaex.es/comunicacion/noticia?idPub=26142#.W8kF0qdRTMJ

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 689687
4.1.8 Cost structure

Important is to have a good view of what is the customer willing to pay in relation to the value proposition. On one side, we have the organisation driven by a maximal cost-reduction. On the other side, the maximum quality driven organisation. Most organisations are somewhere between. This is also the case for Water Future, but a detailed elaboration of the cost structure was not possible at this moment as they are not in a stage of producing and selling systems yet. Important is to have a good insight into the different costs:

4.1.9 Revenue streams

The revenue model for the supplier is strongly related to the business case of the end user and the question for what value the customer is willing to pay.

In general, the savings on water and nutrients will not lead to a short pay-back time, but the additional advantages (e.g., no additional treatment for discharge water needed (NL), a better controlled water system and more consistent water quality, leading to better growth are important topics that can influence the business model. Focussing at these points can affect the revenue model, not only delivering a system and make a profit on this but also delivering a service.

The focus of Water Future is at the delivery of a total solution, but this does not mean that creating income from other activities, like selling a system, component or service will not be used.
### 4.1.10 Summary Business Model CED

<table>
<thead>
<tr>
<th><strong>Key Partners</strong></th>
<th>Suppliers of components, membranes, ..</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Growers,</td>
</tr>
<tr>
<td></td>
<td>Research stations</td>
</tr>
<tr>
<td></td>
<td>NGO’s on environment</td>
</tr>
<tr>
<td></td>
<td>Investor ??</td>
</tr>
<tr>
<td></td>
<td>Builders of Greenhouses</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Key Activities</strong></th>
<th>Promotion via congresses and demo’s</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Development prototype</td>
</tr>
<tr>
<td></td>
<td>Set-up production facility</td>
</tr>
</tbody>
</table>

| **Value Proposition** | Semi-selective removal of mono-valent ions. Closing the water-cycle: Reduce water and nutrient use Fewer emissions to water, less concentrated waste Better Control of the fertigation: solution Lower costs Small system Integrated system |

| **Customer Relationships** | Direct Contact, personal assistance, co-creation? Contact via stakeholders: Research institutes, builders of greenhouses |

<table>
<thead>
<tr>
<th><strong>Key Resources</strong></th>
<th>Market information</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Human resources: Market, production, sales</td>
</tr>
<tr>
<td></td>
<td>Test and production facilities</td>
</tr>
</tbody>
</table>

| **Channels** | Publicity/awareness: demo’s and show-cases with advisors For sales: Direct sales and via equipment and service suppliers |

| **Customer Segments** | Small and medium size Growers: Soilless growth, crops sensitive for Na Suppliers of greenhouse equipment and water systems Service providers |

| **Cost Structure** | Cost of Finance Materials, equipment, utilities, labour |

| **Revenue Streams** | Sell complete product, sell a service Lease contracts, maintenance |
4.2 Business Model for Sodium Removal Unit (SRU) Optima Agrik

4.2.1 Value proposition

Optima Agrik’s Sodium Removal Unit (SRU) uses a combination of the principles of two widespread uses of ion exchange; water desalination and water softening. In the desalination process, positively charged ions are absorbed onto a cation resin, and negatively charged ions are absorbed onto an anion resin producing desalinated water, while in water softening an unwanted ion is exchanged for a preferred ion. The SRU differentiates itself from other (semi)selective sodium removal processes as it recovers all of the nitrate and phosphate in the drain water. Additionally, the SRU produces only a minor waste stream containing the removed sodium. The working principle of the SRU is described in more detail in Annex 2.

![Figure 9 Schematic overview of the working principle of Optima Agrik’s SRU](image)

Optima Agrik’s SRU unit can be applied for the selective removal of sodium from:

1. The fresh water source
2. The drain water to further improve the recirculation process (closing the water and nutrient cycle)

**Ad. 1. SRU for desalination of fresh water sources**

The SRU can be applied for the selective removal of sodium from fresh water sources containing lower concentrations of sodium. For example, an electric conductivity (EC) of 0.3 mS/cm² of the water source has an equivalent of 3 equivalents of total cations. The nitrate concentration is produced at a factor of 1.7. This means that when the produced fertiliser is used at the farms site the final nitrate concentration in the irrigation water will be 5.1 mmol/L. If the required nitrate concentration in the nutrient mixture is 5.1 mmol/L, it means that all the produced fertiliser could be utilised at the farm’s site. In this way, the EC of the water source to be treated and the nitrate demand of the irrigated crop would be in balance.

As a consequence, both the water source and the crop should be considered when evaluating the potential of the SRU for a farm. A crop of roses, for example, requires lower amounts of nutrients. As a consequence, the SRU can, in case of a rose crop, only be used for the desalination of fresh water sources containing lower sodium concentrations. As the fertiliser demand of tomato crops is higher, the SRU can be applied as well for water sources containing higher sodium contents in these cases.
Ad. 2. SRU for selective sodium removal of drain water (closing the water and nutrient cycle)

The SRU also can be applied to remove sodium from the drain water to support enhanced recirculation and in this way reduce the amount of discharged water. Sodium is identified as the main reason or trigger for discharging drain water.

The SRU installation can, in this setting, be used as an additional instrument to desalination technologies, such as reversed osmosis (RO). While the RO installation removes the sodium of the irrigation water source (fresh water input), the SRU will remove the sodium from the recycled drain water.

In this setting, the SRU technology differs from other technologies as:

1. **Sodium is separated from nitrate and phosphate:** In general, from the chemical point of view, it is challenging to separate both sodium and nitrate. The SRU not only separates sodium from nitrate and phosphate but also keeps it separate making it possible to recover 100% of the nitrate and phosphate in the drain water while removing the compound that is preventing the grower from doing so, namely sodium.

2. **High quality fertilisers are produced:** The chemicals used in the regeneration process contain plant nutrients which are recovered and used in the greenhouse replacing some of the fertiliser.

3. **A minimal waste stream is produced:** The sodium is removed in a solution which only makes out 5% of the volume of the treated water. Due to the low volume, one can find cost effective ways of disposing of the sodium.

4. **The saving in fertiliser covers part of the operational costs:** The SRU was already implemented at a commercial greenhouse of 9 hectares in the Netherlands. Daily, 8m³ of drain water was treated. The operational costs amounted €68,31 per day while the savings for the KNO₃ fertiliser amounted €57,50 per day.

Optima Agrik preferred to build the business model on the second option.
In 2017, the SRU was demonstrated at a Dutch commercial tomato greenhouse of 9 hectares. On a daily basis, 8m³ of the drain water was treated by the SRU. On the one hand, daily a waste stream of 400 litres of concentrated sodium chloride solution was produced.

The running costs per day amounted €68,31, and the investment cost amounted at €30, while the savings are valued at €57,50. The investment costs can differ from country to country as interest costs may vary.

<table>
<thead>
<tr>
<th>Resins</th>
<th>€ 1.75</th>
<th>€ 0.20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemicals</td>
<td>€ 53.00</td>
<td>€ 5.89</td>
</tr>
<tr>
<td>Electricity</td>
<td>€ 1.50</td>
<td>€ 0.17</td>
</tr>
<tr>
<td>Dumping of concentrate (NaCl)</td>
<td>€ 12.06</td>
<td>€ 1.34</td>
</tr>
<tr>
<td><strong>Total cost/day</strong></td>
<td><strong>€ 68.31</strong></td>
<td><strong>€ 7.60</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Investment cost</th>
<th>Total</th>
<th>Per ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Investment cost of €60 000 over 10 years</td>
<td>€ 6000/ year</td>
<td>€ 666,67</td>
</tr>
<tr>
<td>Daily Investment cost</td>
<td>€ 20</td>
<td>€ 2.22</td>
</tr>
<tr>
<td>Interest cost of 5%/year</td>
<td>€ 10</td>
<td>€ 1.11</td>
</tr>
<tr>
<td><strong>Total cost/day</strong></td>
<td><strong>€ 30</strong></td>
<td><strong>€ 0.42</strong></td>
</tr>
</tbody>
</table>

| Direct fertiliser savings due to the chemicals that replace KNO3 | € 52.00 | € 5.78 |
| Indirect savings due to drain water not dumped | € 5.50 | € 0.61 |
| **Total savings/day** | **€ 57.50** | **€ 6.39** |

The total daily costs are valued at €98,31/day which brings the cost to €12,29/m³ while the revenue stream is valued at €57,50/day or €7,19/m³. The cost will slightly decrease every year as the interest cost will reduce per year.

The investment cost itself is rated between €50,000 to €70,000 for this company. In the calculation, besides we used €60,000 as the basis for the calculation.

The SRU process ensures that discharged water does not need to be transported and treated by an approved processor. The cost of transport and treatment of discharged water by external companies depends on the country of the grower and would have to be sorted out per country as prices may differ — for example, prices in Belgium range between €45 and €60 or even more. Taking these savings in costs into consideration is important.
4.2.2 Customer segments

As described in the value proposition section, Optima Agrik opts to implement the SRU as a technology for optimising the drain water recirculation. This approach is essential for the identification of the end-user segment and will have his effect on the channels that will be used. Consequently, the end-user segments will depend on:

a. The applied growing system:

Closure of the water and nutrient cycle is mainly relevant for farms already applying (semi-) closed growing systems. Semi-closed and closed systems are mainly applied in covered growing systems, mainly greenhouses. Between the most important European countries regarding to the surface covered with greenhouses, we identify Spain, Italy, the Netherlands, and France. The areas of soilless horticulture are mainly located in the north western European region being the Netherlands, Belgium and the north-western part of France.

Table 6 First indication of the geographical spread of soilless covered growing systems applying recirculation

<table>
<thead>
<tr>
<th>Country/Region</th>
<th>Surface of covered crops (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spain</td>
<td>70.0009</td>
</tr>
<tr>
<td>- Almeria</td>
<td>31.6149</td>
</tr>
<tr>
<td>- Huelva</td>
<td>12.7019</td>
</tr>
<tr>
<td>- Canary Islands</td>
<td>6.0859</td>
</tr>
<tr>
<td>- Murcia</td>
<td>5.86810</td>
</tr>
<tr>
<td>- Granada</td>
<td>3.0879</td>
</tr>
<tr>
<td>Italy</td>
<td>39.85211</td>
</tr>
<tr>
<td>France</td>
<td>10.00012</td>
</tr>
<tr>
<td>The Netherlands</td>
<td>8.84413</td>
</tr>
<tr>
<td>Belgium</td>
<td>1.93014</td>
</tr>
</tbody>
</table>

9 Avance Anuario de Estadísticas 2017
10 As published by the Centro Regional de Estadística de Murcia in 2017
12 http://www.legumesdefrance.fr
b. Sodium and chloride content of the fresh water

The fresh water source is identified as the primary input of sodium (cfr. Section 4.1.1) in recirculation systems. Water sources containing higher sodium contents will lead to sodium accumulation in these systems. Fertilisers and/or disinfection products also may contribute to sodium accumulation. Depending on the cultivated crop, higher or lower threshold values can be maintained for the sodium concentration. Once the sodium concentration exceeds the threshold value, one might risk yield and/or quality losses. Higher sodium concentrations are observed in coastal areas where sea water intrusion occurs (cfr. Almería, Murcia).

Optima Agriks’ SRU is mainly relevant for farms who apply water sources with a low chloride concentration. The water needed to supplement the rain water must have low chloride concentration. The sodium concentration of the supplement water is determined by the ratio of rain to supplement water. For example, if 75% of the total water supply is rain water, the SRU can treat water with an EC of 1,2 mS/cm for roses.

In the case of farms that want to re-use the drain water, complete removal of sodium from the water is required while in other cases the sodium concentration could be lowered to acceptable levels.

c. Crops sensitiveness for sodium

Depending on the crop and the region, growers consider specific threshold values for the maximal sodium content in the recycled drain water.

In the Netherlands, for example, the threshold value for soilless grown crops applying recirculation was set on 6 mmol/l for sweet pepper crops, while it was set at 8 mmol/l for tomato crops. More recent research has shown that higher threshold values of 10mmol/l can be maintained for sweet pepper or even 17 mmol/l for tomato. These outcomes result from the first set of demonstrative trials set up by WR in 2018\textsuperscript{15}. In the MED, region, tomato crops are grown in open to semi-closed systems applying nutrient solutions containing sodium concentrations of 20 mmol/l for salad tomatoes, 25 mmol/l cherry tomato or even 50mmol/l for the local Almerian raf tomatoes\textsuperscript{16}.

d. Willingness to invest

The end-user’s willingness to invest in technologies is also a crucial factor. In the framework of the FERTINNOWA Benchmark survey (2016), growers were asked about their actions planned to limit effluent discharge into the environment. In general, the benchmark survey showed a higher interest in technologies for waste water treatment in the north western region compared to the Mediterranean or central eastern regions. The highest proportion of growers planning to implement new practices was found in Belgium and the Netherlands.


\textsuperscript{16} D5.4 Evaluation report of on-site implementation of technologies to improve water use efficiency for soillesse crops.
Greenhouses with soilless cultures in the Netherlands and Flanders are forced by law to evolve towards zero emissions (both for nutrients and crop protection products). For these companies, the closure of the water cycle is a good alternative as this can reduce the need for end-of-pipe solutions to treat discharge water\(^{17}\).

\[\text{e. Other}\]

In the framework of the FERTINNOWA technology exchanges (WP5), the SRU unit was preliminarily evaluated in the Mediterranean region (Almeria) but after a first analysis, the recovery of nutrients to be used as fertilisers, the high initial investment cost and as well some regional normative constraints about the waste stream, made the technology less suited for these specific conditions (D5.4).

Based on the above described factors, OA opted to focus first on the Flemish and Dutch greenhouse segment applying recirculation. Other regions or segments, however, are not directly excluded. As mentioned above, mainly the combination of the initial water quality, the desired sodium level and the nutrient demand of the crops are essential to evaluate the SRU’s potential for a company or region.

\[\text{4.2.3 Customer relationships}\]

Optima Agrik is the first point of call for interested growers in Optima Agriks country, South Africa. In other countries, the company has set up collaborations with the Dutch company Horticoop (the Netherlands, Germany, and Denmark) and the Flemish/Dutch company Verhoeve Milieu & Water (Belgium). These collaborations are meant to build and distribute the technology in different countries. Collaborations in different countries are also set up to guarantee a professional and personal approach with the growers.

In the preliminary phase of the sales contact, Optima Agrik will support the suppliers in their research at the grower’s site. Also, support will be provided to the development if the SRU installations being built by Verhoeve and Horticoop. Once the suppliers approve that the technology is suited for the customer, Optima Agrik will support the start-up of the technology.

Once the technology is installed and running, Optima Agrik will give the service to do fine-tuning the technology to make sure the installation operates at its best. Optima Agrik is also the first point of contact in other countries where Verhoeve and Horticoop are not operational. Therefore, interested growers can contact Optima Agrik via phone, mail, LinkedIn, and in the future via a website.

To guarantee the best service for its customers, the company envisage providing a 24/24 hours’ service that can be used in case of problems. Technical support will be provided remotely by the technology suppliers to give an optimal customer experience.


This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 689687
This concludes that Optima Agrik has chosen for a personal approach with his customers. Even when Optima Agrik is not the first point of contact they want their distributors to have the personal approach. Also maintaining contact is very important.

### 4.2.4 Channels

Optima Agrik selected the following channels to reach the target groups:

**Table 7 Channels for Optima Agrik**

<table>
<thead>
<tr>
<th>Channel</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Word of mouth:</strong></td>
<td>The most powerful channel to convince other growers to buy the products is the use of word of mouth. This means that the company gets free marketing and exposure to other growers. Growers that are satisfied or impressed by the technology will transfer their knowledge on the product and give free exposure to other growers.</td>
</tr>
</tbody>
</table>
| **Technology suppliers:** | - Horticoop  
- Verhoeve Water & Milieu |
| **Website:** | Use a website as a general point of information. At this moment Optima Agrik does not have a website, but this will be built in the future. From the project of FERTINNOWA, we strongly recommend to build a website, so interested growers can easily find more information and contact details. To optimize the leads to the website, links should be inserted in other websites. |
| **Participation in projects:** | - FERTINNOWA (Europe)  
- Zunurec (Belgium)  
- ... |

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Transfer of INNOvative techniques for sustainable Water use in FERtigated crops

<table>
<thead>
<tr>
<th>Technology fairs:</th>
</tr>
</thead>
<tbody>
<tr>
<td>- International:</td>
</tr>
<tr>
<td>- Greentech trade show Amsterdam (The Netherlands)</td>
</tr>
<tr>
<td>- IPM Essen Messe (Germany)</td>
</tr>
<tr>
<td>- Agriflanders Belgium</td>
</tr>
<tr>
<td>- Amsterdam international water week (The Netherlands)</td>
</tr>
<tr>
<td>- Aquatech Amsterdam</td>
</tr>
<tr>
<td>- HortiContact Gorinchem (The Netherlands)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Offline magazines:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Belgium:</strong></td>
</tr>
<tr>
<td>- Proeftuinnieuws</td>
</tr>
<tr>
<td>- Management en techniek</td>
</tr>
<tr>
<td>- Sier teelt en groenvoorziening</td>
</tr>
<tr>
<td><strong>The Netherlands:</strong></td>
</tr>
<tr>
<td>- Onder glas</td>
</tr>
<tr>
<td>- Groenten en fruit</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Online magazines:</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Glastuinbouw waterproof</td>
</tr>
<tr>
<td>- Hortinext</td>
</tr>
<tr>
<td>- Hortidaily</td>
</tr>
<tr>
<td>- AGF</td>
</tr>
<tr>
<td>- Vilt</td>
</tr>
<tr>
<td>- Newsletters demonstration sites</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Linkedin profile</th>
</tr>
</thead>
<tbody>
<tr>
<td>The use of social media platforms has significantly increased in the last 10 years. Also, a lot of the growers are active on these platforms. Therefore we recommend creating a professional account on LinkedIn about Optima Agrik, where they can publish relevant articles or interesting videos about the technologies. Also, their evolution in the technology can be published on this profile. With this channel, the following people can be reached: interested growers, research institutes,</td>
</tr>
</tbody>
</table>

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 689687
Long-term proposition

Google Adwords:

Once the website is up and running, a good advertisement may be needed to get interested growers to visit the website.

Making an advertisement on google that will only appear when specific words are being searched or when the intended target group searches for general topics on the internet. The correct use of search engine optimisation (SEO) and search engine advertising (SEA) will make sure that the target audience will be reached efficiently.

The use of specific keywords in the advertisement will make sure that the right target audience is being reached. This is a costly way of advertising and depends on the settings whether you choose to pay per click or per view.

The above mentioned channels will create more brand awareness and generate more leads to the selling companies. With efficient use of all these channels, the right audience will be reached, and more sales will be generated.

4.2.5 Key partners

The key partners that ensure the successful installation of the unit, the implementation and continued support of the process are the following:

- Current suppliers of the irrigation equipment will take responsibility for the marketing, installation, monitoring, and maintenance of the SRU.
- Manufacturers of the units. The unit for the SRU process is very similar to units for other water treatment processes. So any company that builds reverse osmosis or fertilisation units can also build the SRU.
- Supplier of the resins and the chemicals
- For the disposal of the chloride concentrate, a transport company and a waste company are key partners.

Horticoop is a Dutch technology supplier who serves the SRU’s customer segment in the Netherlands, Germany, and Denmark. Over recent years, Horticoop has developed to become, among other activities, a leading supplier and developer of advanced horticultural technology and a producer of high-grade substrates. The added value of these products and services - in the form of innovation, expertise, and service - has been increasingly acknowledged by the industry.

Verhoeve Milieu and Water acts both as a technology developer and technology supplier to serve the SRU customer segment in Belgium, mainly Flanders. Verhoeve was one of the first companies offering mobile purification installations in the Netherlands to remove plant protection agents from discharge water. The company now also has an interest in mobile units for nutrient and sodium removal. Nevertheless, Verhoeve can also provide permanent installations at the farms’ site.
At this stage, the customer’s segment in France (Bretagne, ...) is not covered yet.

4.2.6 Key activities

1) Optimisation of the SRU: The first and most important activity
2) Evaluation procedure as described below.
3) Screening other fields of implementation for ion exchange in horticultural sector

The SRU process produces fertiliser that must be used by the grower on the site where it is produced. This means on the greenhouse for which the water is treated. This is essential because the cost effectiveness of the process is based on the requirement that the fertiliser budget of the grower covers the running cost of the process. Therefore, aspects that seem entirely unrelated to the treatment of water should also be considered.

These include:

- The water sources used on the greenhouse, volumes, and quality and when it is used during the season.
- The drain water composition and preferably a record of the analysis over a production season.
- The fertiliser used on the greenhouse, type and if it is specifically low in sodium to enable re-use.
- What steps the grower has already taken to reduce the volume of discharge from his greenhouse.

The above information is used to get a complete picture of the greenhouse regarding where the sodium comes from and how it is currently removed from the greenhouse. In the process, it is also important to determine where the chloride is coming from and where it is going since mechanisms that are removing the sodium might also be responsible for the removal of chloride. In such a case it will not be useful to implement the SRU which is only removing the sodium.

Once there is a clear picture of the sodium and chloride balance in the greenhouse, the best way to evolve towards zero emission can be determined for the company. In some cases, it might be better to treat the source water rather than the drain water.

If it is concluded from the investigation that the SRU is the right solution for the grower the size of the unit will be determined and the grower will be quoted. Once the unit is installed, the unit must also be monitored to ensure continued operation. The water must also be analysed regularly to ensure that the process works effectively.

The key activities can, therefore, be summarised as follows:

1. Evaluation of greenhouse operation
2. Determining the correct solution for the greenhouse
3. Quote the customer
4. Install the SRU unit
5. Monitor the process
4.2.7 Key resources

- Financial and legal means:
  o Start-up capital
  o Contracts
  o Patents
  o Projects (FERTINNOWA, ...)
  o Law (cfr. Legislation in Flanders and the Netherlands related to discharge of drain water leads to higher interest of the growers to invest in technologies allowing selective sodium removal)
  o Crowdfunding

- Intellectual resources:
  o Know how
  o Patents
  o Brand
  o Partnerships

- Human resources:
  o Production
  o Sales
  o Maintenance
  o CRM
  o Follow up on projects

- Operational resources:
  o Production place
  o Network of distributors and transport firms
  o Laboratory and facilities
  o Meeting room, office, buildings

- Suppliers of chemicals such as, potassium chloride (KOH) and nitric acid (HNO3) for the regeneration of the absorbed cations.
  o Raw materials, water, electricity
  o Software
  o Suppliers resins for the ion exchange column
  o Suppliers of valves – piping – pressure vessels – control equipment
  o Suppliers of sand filtration (or pre-filtration step)
  o Suppliers of extra storage facilities for the produced fertilisers

4.2.8 Cost structure

The cost structure of Optima Agrik exists of 3 main costs. The first one is the main costs that will cover costs for R&D of the technology. The second part includes the daily operating costs of the company, and the last topic consists of costs for technology support.

- Main costs for R&D of the technology:
  o Research costs
  o Outsourcing
  o Small scale tests/ lab tests
  o Personnel costs
- Modelling costs

- Operating costs
  - Travel costs
  - Exhibitor costs for participating in technology fairs
  - Infrastructure costs

- Technology support:
  - Software

4.2.9 Revenue streams
The revenue streams of Optima Agrik are limited due to its cross-border sales. In the other countries like Belgium, The Netherlands, France, etc. other companies will take over his sales. These companies are called licence keepers, and they have bought the knowledge of Optima Agrik. A potential list of revenue streams is shown below.

- Sales of licences
- Support to suppliers
- Support from projects
- Support from authorisations (subsidies, …)
- Crowd funding
### 4.2.10 Summary Business Model SRU

<table>
<thead>
<tr>
<th>Key Partners</th>
<th>Key Activities</th>
<th>Value Proposition</th>
<th>Revenue Streams:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- Optimisation of the SRU</td>
<td>- <strong>SRU for desalination of fresh water sources</strong>&lt;br&gt; - <strong>SRU for selective sodium removal of drain water (closing the water and nutrient cycle)</strong></td>
<td>- Sales of licences&lt;br&gt; - Support to suppliers&lt;br&gt; - Support from projects&lt;br&gt; - Support from authorisations (subsidies, …)&lt;br&gt; - Crowd funding</td>
</tr>
<tr>
<td>- Suppliers</td>
<td>- Evaluation procedure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Supplier of resins</td>
<td>- Evaluation of greenhouse operation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Transport company</td>
<td>- Determining the correct solution for the greenhouse</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Waste company</td>
<td>- Quote the customer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Horticoop</td>
<td>- Install the SRU unit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Verhoeve Water &amp; Milieu</td>
<td>- Monitor the process</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Working IEX</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Key Resources</th>
<th>Customer Relationships</th>
<th>Customer Segments</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Financial and legal means</td>
<td>- Personal approach&lt;br&gt;</td>
<td>- The applied growing system&lt;br&gt;</td>
</tr>
<tr>
<td>- Intellectual resources</td>
<td>- 24/7 service</td>
<td>- Sodium and chloride content of the fresh water&lt;br&gt;</td>
</tr>
<tr>
<td>- Human resources</td>
<td></td>
<td>- Crops sensitiveness for sodium&lt;br&gt;</td>
</tr>
<tr>
<td>- Operational resources</td>
<td></td>
<td>- Willingness to invest&lt;br&gt;</td>
</tr>
<tr>
<td>- Suppliers of chemicals</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cost Structure</th>
<th>Channels</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Research costs</td>
<td>Publicity/awareness: demo’s and show-cases with advisors&lt;br&gt;</td>
</tr>
<tr>
<td>- Outsourcing</td>
<td>For sales: Direct sales and via equipment and service suppliers</td>
</tr>
<tr>
<td>- Small scale tests/ lab tests</td>
<td></td>
</tr>
<tr>
<td>- Personnel costs</td>
<td></td>
</tr>
<tr>
<td>- Modelling costs</td>
<td></td>
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<tr>
<td>- Travel costs</td>
<td></td>
</tr>
<tr>
<td>- Exhibitor costs for participating in technology fairs</td>
<td></td>
</tr>
<tr>
<td>- Infrastructure costs</td>
<td></td>
</tr>
<tr>
<td>- Software</td>
<td></td>
</tr>
</tbody>
</table>
4.3 Business Model for DSS

4.3.1 Introduction

Future impacts of climate change will differ from region to region around the world. Anticipated effects include increasing global temperatures, rising sea levels, changing precipitation, and expansion of deserts in the subtropics. Likely changes include more frequent extreme weather events such as heat waves, droughts, heavy rainfall with floods and species extinctions due to shifting temperature regimes. Effects significant to humans include the threat to food security from decreasing crop yields and the abandonment.

Possible societal responses to global warming include mitigation by emissions reduction and adaptation measures, like, building systems resilient to its effects.

Threats that are relevant for the horticulture sector related to water are:
- Change in water requirement of crops
- Change in water availability by drought or flooding (climate change induced extreme weather events)

Climate change will also affect water availability. The Mediterranean area is specifically projected to experience a decline in water availability, and future irrigation will be constrained by reduced run-off and groundwater resources, by demand from other sectors and by economic costs.

Europe’s freshwater resources are under increasing stress, with a mismatch between demand for, and availability of, water resources across both in time and spatial scales (EEA, 2012). Water stress already affects one third of the EU territory all year round, and water scarcity and drought are no longer issues confined to southern Europe. Despite their temperate climate, regions in northern European countries, including UK and Germany, are also faced with seasonal water stress. Freshwater sources are under pressure from the increasing demands for water from growing populations and industrial use supporting their economies. As an effect of climate change, the frequency and intensity of droughts and their environmental and economic damages appear to have increased over the past thirty years (EC, 2012).

In some countries in Europe, more than 80 % of the total freshwater abstraction is used for agricultural purposes (irrigation). Crop water demand (the water consumed during the growing season), depends on the crop type and the timing of the growing season. Some of the effects of estimated changes in the crop water deficit may also be related to the duration of the crop growing period, which is shortened under higher temperatures, thus leading to less water being consumed.

The simulations for both climate model projections for the 2030s show an increasing crop water deficit for large areas of Europe, in particular over central Europe. This will increase the water requirement for irrigation, including in areas where irrigation is not currently applied. Adaptation measures and the integrated management of water, are needed to address future competing demands for water between agriculture, energy, conservation, and human settlements. New irrigation infrastructure will be required in some regions.
The impact of increasing water requirements is expected to be most acute in southern and central Europe, where the crop water deficit and irrigation requirements are projected to increase. This may lead to an expansion of irrigation systems, even in regions currently without irrigation systems. However, this expansion may be constrained by projected reductions in water availability and increased demand from other sectors and for other uses.

Optimising irrigation at the farm level requires providing the right amount of water at the right time to cover the needs of the crop at that moment. Proper irrigation management will foster a good yield and quality of the crops. The crops water needs vary with crop development, weather conditions, soil type, and other site-specific factors. Poor irrigation management can reduce the yield and quality of the harvested products. These losses can occur either due to an excess or a lack of water at critical growth stages of the crop.

Knowledge of the crop’s water needs is essential. Monitoring technologies of the soil or the crop can provide vital information to guide irrigation management regarding the timing and amounts of irrigation. Insights into the crop water requirements and the implementation of monitoring technologies can foster implementation of irrigation management strategies.

Poor irrigation scheduling can lead to a loss of quality and productivity of the crop, either due to an excess or a lack of water supply at critical crop growth stages. Knowledge of crops water requirements is the first factor to consider. It will enable fulfilment of crop’s water demand in every moment of its cycle. However, in many cases, this calculation is complicated. Due to climatic variability, it is necessary to use different local sensor systems to obtain quantified differences of irrigation applied at every geographic zone. On the other hand, the determination of water requirements for each crop is in many cases not realistic; it is a theoretical calculation that must be contrasted by the grower on his farm, requiring different tools or technologies that enable direct verification if the crop is consuming the full volume of supplied water.

These are the main problems that farmers face when managing irrigation of their crops:

- Correct estimation of the crop water requirements
- Irrigation strategies adapted to different crops
- Adjustment of the irrigation strategies to plant and soil water status.

Information about water requirements and irrigation strategies can be used to develop a decision support system (DSS) which can be used to advise growers on irrigation scheduling. DSS is a computer-based information system that supports organisational decision-making activities, typically resulting in ranking, sorting, or choosing from several alternatives. A properly designed DSS is an interactive software-based system intended to help decision makers compile useful information from a combination of raw data, documents, and personal knowledge to identify and solve problems and make decisions.

References:
Generally, DSS incorporate simulation models. The advances in computer science with the development of Information and Communication Technologies and the improvement in communication systems have revolutionized the possibilities of integrating crop monitoring sensors in DSSs. These DSSs are based on the measurement of different sensor types (soil moisture measurement and plant water sensors) that enable real-time corrections of the initial estimations obtained by the model. The system starts with the development and implementation of a crop needs model, calculating crop water requirements from agrometeorological historical data, or using data from a nearby agrometeorological station adjusted with crop-specific coefficients, or estimated from crop development curves, or measured in the field with digital images. However, these systems oblige farmers to make choices when interpreting the obtained data. It is a time-consuming activity, and a good technical background for correct interpretation is required. (more information in WP 4.1. Documents: Fertigation management, Irrigation management).

Automation systems such as IRRIX enable the integration of a DSS with field sensors. This permits an anticipated estimation of irrigation needs based on a mechanism of readjustment by feedback control of soil and weather sensors. This readjustment is made automatic and reduces the need for data interpretation by growers. In order to introduce the possibility of corrections for a better adaptation of water management to the grower’s needs, machine learning is also implemented.

IRRIX DSS enables the reduction of existing gaps about the correct programming of irrigation and fertilization strategies adjusted to real and in-time crop needs. This might help to reduce overwatering and over fertilization of crops.

4.3.2 Value proposition

The proposition described in this section is the use of the IRRIX automatic irrigation system based on a DSS and in combination with a sensors tool to support irrigation management and supervision. In particular, this has been developed for drip irrigation systems (open field and greenhouse) although its use could be extended to further scenarios. Its overall objective is to reduce the bottlenecks and gaps as referenced in D4.1:
Transfer of INNOvative techniques for sustainable Water use in FERtigated crops

- To offer a cost-effective tool that provides the end-users (farmers or technicians) effortless irrigation management.
- Secure and reliable supervision of the state of the irrigation system.
- To relieve farmers from most of the tasks involved in acquiring data, scheduling, and supervising the application of efficient irrigation.
- To help growers to adjust the irrigation doses to the crop water status in each phenological stage.
- Adjustment of the irrigation strategies to plant and soil water status.
- To help growers in the application of deficit irrigation strategies: saving water, reducing vegetative growth (pruning), keeping yield levels and fruit quality.
- Adjust irrigation dose to the existing soil and plot variability.

The IRRIX system complements the functionalities of current irrigation and fertigation control equipment by making them part of a higher-level system based on Information and communications technology (ICT). The role of that high-level system is the integration of data and information from multiple sources for their usage in automated scheduling decisions and supervision. It can also facilitate user interaction with the system and communication between people involved in the process. The irrigation controller remains as a key component for the execution of irrigation schedules with some autonomy. What makes the difference is that those schedules will be remotely and daily updated for each irrigation sector. For every subsequent application, the precise crop water needs will be estimated as a function of weather conditions, the soil and crop water status assessed by sensors, as well as to the productive and environmental goals set by the grower. For this purpose, weather data and sensor measurements are combined in a base of state-of-the-art agronomic knowledge. Machine-to-machine communications and design of the application aim to reduce the need for user intervention in operational tasks and instead focus its participation in strategic decisions.

IRTA developed the IRRIX web platform for monitoring and automated irrigation control. IRRIX system has been calibrated, among others in a Spanish national research project (INIA RTA2013-00045-C04) in different crops (tomato, pepper, plum, nectarine, olive, almond and apple) and different systems (open field and greenhouse) in different plots of Lleida, Badajoz and Almeria (Spain). It was previously developed as one of the objectives of the European Project Effidrip (www.effidrip.eu)

IRRIX system is formed by two components: a) sensors installed in the field, and b) web platform whose algorithm results from a combination of water balance with soil moisture sensors feedback adjustment mechanism.
a) Sensors installed in the field: (1) Soil moisture sensors, (2) Air temperature sensor, (3) solenoid valve, (4) water meter, (5) datalogger with modem, (6) IRRIX serve

b) Web platform hosted in the cloud that carries out the following daily tasks:

(1) Data collection of sensors installed in the field. IRRIX downloads sensor data at periodic intervals during the day. The reference evapotranspiration (ETO) is daily estimated from the air temperature sensor, using the Hargreaves equation (Hargreaves and Allen, 2003).

(2) Analyse all data and calculate irrigation water volumes. IRRIX analyses all incoming data to find out anomalies and detect if any important event has occurred in the system (irrigation, rain). Then, IRRIX analyses the set of data to determine the irrigation dose and adjusts the irrigation dose with the information provided by the soil sensors. To do so, the tool integrates a water balance model.

(3) Interact with users. IRRIX is an autonomous system whose main objective is to free the user from work. The main function of the user is to check that the system has worked correctly and that the irrigation season has gone on as expected. Also, should there be any anomaly in the system, the user must resolve the anomaly.

(4) Irrigation scheduling. IRRIX sends the updated irrigation doses to the data logger. Then, this device will order to turn on the rest of the equipment (solenoid valve) for applying the irrigation doses and stop when water dose scheduling is apply indicated by water-meter.

Also, before starting the irrigation season, the user must upload in IRRIX a seasonal plan that would roughly foresee how watering will be distributed throughout the irrigation season. For this, a set of curves must be defined, and the automated control system must operate between those curves (limits of the system) so that the system must always move between a maximum and a minimum of accumulated irrigation.
Transfer of INNOvative techniques for sustainable Water use in FERtigated crops

IRRIX-DSS AUTOMATIC IRRIGATION SYSTEM

IRRIX-DSS enables the adjustment of the irrigation grower’s schedule to soil water content and soil water balance. The system calculates irrigation supply between the pre-established maximum and minimum watering thresholds. Depending on the grower’s confidence on the system, threshold limits may be wider which would give more room for automated optimization and reach water savings between 25-50% depending on the grower, soil, and crop. Savings in fertilizers may be significant as a side effect of the reduction of lixiviation associated with overwatering.

IRRIX intends to serve as a complement to some irrigation programmers currently available in the market, which offers the possibility of daily optimization of the programming without the need for user intervention, as well as to supervise the correct operation of the irrigation system based on real observations of the sensors.

References:

4.3.3 Customer segments

The customer’s segments as expressed in the IRRIX-DSS canvas model sections are technical managers and advisors, or collectives such as agricultural cooperatives and irrigation communities.

The benchmark survey conducted by FERTINNOWA showed that growers apply multiple tools and practices to support their irrigation management. 33% of the growing systems reported applying 1 to 3 tools. However, some regional differences were observed. The benchmark survey revealed the low automation level of the supporting tools. In general, 49% of the reported tools used were applied manually. Automated tools were mainly reported for soilless protected growing systems to monitor weather parameters and water and drain water volumes.

The surveyed growers expressed willing to shift towards more automated sensors, but costs were reported as the primary bottleneck. Growers may not see the cost of these technologies as a worthwhile investment considering the financial returns that directly result from their use. The economic benefits for growers will most likely be indirect regarding reduced purchases of water, reduced vegetative growth (less pruning), but keeping yield levels and fruit quality.

Implementation of sensors supporting irrigation management requires a minimal level of agronomic knowledge from the grower’s side. This knowledge is essential to interpret the crop’s water requirements and to adapt the irrigation practices according to the growth stage as well as the strategy of irrigation and the water state in the plant and the soil.

Another issue influencing the adoption of these technologies by growers will be their attitude and familiarity with information and communication technologies. Many of the technologies for improving irrigation management involve the use of smart technologies such as computers, the internet, smart phones, sensors, etc. Older and less educated growers are likely to be more resistant to adopt such technologies. Based on the benchmark survey, it was shown that for 57% of the cropping systems the irrigation schedule was adjusted throughout the growing season based on the grower’s experience. These adjustments were mainly based on the crop appearance and/or the soil or substrate. In 20% of the cropping systems, this crop and soil/substrate appearance was the only way to monitor the irrigation management.

This technology can be transferred and managed by supply companies, as they can acquire a greater knowledge of the technology and transfer its use to the final farmer, in such a way that it can support in reducing the bottleneck in the incorporation of the technology in the field. This opens the possibility of the integration of technology companies and farmers for a common objective the efficient management of water in crops.

IRRIX-DSS systems can be applied at any region, provided models are adapted to the management requirements in each zone and thus adapted for the maximum required crop irrigation rates, geographical area, and variability, irrigation method (surface, sprinkler, drip irrigation), or land use system (open field and greenhouses). IRRIX enables the automatization of irrigation scheduling after introducing in the model the grower’s irrigation set points. The system
will then adapt a smart management water supply strategy at the most important crop phenological stages. It is easy to manage, and the system can, and must be installed by the local supplier or distributor. Their role is of key importance since specific adaptation to each grower is essential. Just plug and play would not be a feasible option.

### 4.3.4 Customer relationships

The customer's relationship of IRRIX-DSS canvas model sections are:

1. Between the system and end, users will lay on the supplier or installer shoulders. They will adapt the system to each specific case, identify grower´s needs, and determine how the irrigation management strategy might be improved. It is on their responsibility to guarantee adequate setup, required maintenance and correct operation, and avoid wrong recommendations and eventual crop damage.

2. Personal relations with farmers: Word of mouth. Farmers may notice significant savings in water management, also time saved for decision-making. Where the system will be used, neighbouring growers can see its advantages in real and in-field situations, peer to peer dissemination.

3. Knowledge advice to associations. The farmer’s associations and irrigation communities facilitate recommendations and control strategies to their partners. The output of the IRRIX-DSS will optimise the required investments for purchases and storage facilities. In the same way, irrigation communities can decide at each moment how much water is needed in each area and divert water from other basins to couple availability of water and demand. Areas that need more to those that need less.

The system can adapt its recommendations to each type of farmer, farm and technical knowledge. User friendly; it is a system that grows with the farmer and learns from adopted management strategy and system knowledge. It is of great importance to keep farmers away from not understanding the benefits of the system and encourage them to be persistent in its use since it is a medium-term investment.
### 4.3.5 Channels

The channels of IRRIX-DSS canvas model sections are:

<table>
<thead>
<tr>
<th><strong>Table 8 channels of IRRIX-DSS</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Website:</strong> Explanatory videos, manuals, practical cases, and cases of success can be included. <a href="http://www.agriprecddss.com/es/irrix-3/">http://www.agriprecddss.com/es/irrix-3/</a></td>
</tr>
<tr>
<td><strong>Technology fairs.</strong> The system can be explained, shown and transferred to a professional audience.</td>
</tr>
<tr>
<td><strong>Youtube video:</strong> We can use this channel to introduce technology and to give an explanation on how it works.</td>
</tr>
<tr>
<td><strong>Online magazines:</strong> Specialized magazines with articles explaining the use of the system in research projects and commercial plots.</td>
</tr>
<tr>
<td>- Agronegocios</td>
</tr>
<tr>
<td>- Interempresas</td>
</tr>
<tr>
<td>- Innovagri</td>
</tr>
<tr>
<td><strong>Offline magazines:</strong></td>
</tr>
<tr>
<td>- Vida rural</td>
</tr>
<tr>
<td>- Horticultura</td>
</tr>
<tr>
<td>- Agricola vergel</td>
</tr>
<tr>
<td><strong>Word of mouth:</strong> The most powerful channel to sell your products is the use of word of mouth. This means that the company gets free marketing — irrigators associations. The system can be tested in these associations which could be the right channel for sale to individual farmers who are likely to use it.</td>
</tr>
<tr>
<td><strong>European and national project webpage:</strong> FERTINNOWA Report linked with showcase events and technologies exchanges. Smark-ak is Technology Fatsheet</td>
</tr>
<tr>
<td><strong>Facebook and Twitter</strong></td>
</tr>
</tbody>
</table>
4.3.6 Key partners

The key partners of IRRIX-DSS canvas model sections are:

1. Local supplier: The system must be installed by a local supplier, on contract or as a staff member of the area distributor. Local suppliers enable a reduction of the costs linked with setup and maintenance and have a good knowledge of the territory and sector — good marketing opportunities.

2. Irrigation installers could incorporate this product into their product portfolio and make a difference with other installers.

3. Companies selling irrigation programmers could improve their technologies by incorporating the IRRIX-DSS system to their irrigation control devices.

4. Irrigation associations. These associations can advise farmers on the use of these systems to improve water and fertilizers management practices among their associates. Also, by supporting changes in water and fertilizers management practices towards more efficient systems by reducing costs and improving effectiveness.

5. Farmers. The support by farmers showcasing the system would help to incorporate other local farmers.

6. FERTINNOWA and EU. By financing showcase events (in each region.

7. Research institutes. Calibration of the system for adjustment to new crops, system improvements, new types of irrigation systems for a better adaptation of the system. Ease transfer to farmers of efficient management practices of irrigation — integration of the system in other studies or research projects.

8. Advisors

![Diagram of key partners](image.png)

*Figure 14 working scheme of advisors*
4.3.7 Key activities

The key activities of IRRIX-DSS canvas model sections are:

1. Study the standard water and fertilizer management practices in the region. Evaluate existing problems in the areas to improve efficiency. Which are the potential users who may access the system? The technical level of potential users. Know water and fertilizers costs of the major crops in the area, and savings that the system can produce in order to adjust the use or purchase cost.

2. Demonstration (normal scheduling vs. IRRIX-DSS). Demonstration activities of the system will be carried out versus traditional crop management strategies, through technical assistance within collaboration with public and private research centres for the conducting of the trials. In these tests, the different amounts of water and applied fertilizers will be evaluated and assessed, and then savings will be identified together with the resulting yield and quality.

3. Technical documents and background information (key performance parameters). Documents of advantages of using this system.

4. Need for knowledge transfer. Transfer measures will be carried out at the local level to adapt the explanation of the system to the needs in each area, adjusting the system to needs and requirements. To do so, local companies with good knowledge and reputation should be available.

Designing web-based software and integrated systems incorporating the defining parameters of farmer type and other specific characteristics

4.3.8 Key resources

The key resources of IRRIX-DSS canvas model sections are:

1. Local supplier: The system must be installed by a local supplier, on contract or as a staff member of the area distributor. The system will be installed in the field, and the grower should specify a season framework including the min max water supply thresholds to upload in the system. Once validated will automatically issue irrigation recommendations.

2. Adapt the system to different technological partners manufacturers of sensor systems. This may enable the integration of the system in the distributor’s network.

3. Integration of IRRIX-DSS with existing Irrigation Programmers. IRRIX parameters will be adjusted to enable communication with commercial programmers and reduce the costs in those plots with previously installed irrigation controllers.

4. Technical support to overcome the impact of software incidents.

5. Agronomic support to revise any system alarm.

6. Development of an automatic communication system of alarms.
4.3.9 Cost structure
- Maintenance (technical dependence). 1 Agronomist (30,000 €/year) and 1 software analyst (24,000 €/year). TOTAL: 54,000 €/year
- Marketing (major provider cost)
- Research/development
- Integrate new crops or new irrigation techniques and sensors to the system.

4.3.10 Revenue streams
Revenues will be directly collected from the supplier or distribution agent in each territory or country. The supplier will install the required and user-specific control systems. Install costs, maintenance and sensors will be charged to the end user. Renting could be an option.

The IRRIX system will charge an amount of 500 € per year per system user. Service costs will be charged to the installer (no farmer payment). If no local installer would be available, other installers should be contacted within the same region or country.

This requires a minimum of 100 users in operation to balance costs (50,000 €) for a proper system technical maintenance.
### 4.3.11 Summary Business Model DSS

<table>
<thead>
<tr>
<th>Key Partners</th>
<th>Key Activities</th>
<th>Value Proposition</th>
<th>Customer Relationships</th>
<th>Customer Segments</th>
</tr>
</thead>
</table>
| - Local supplier  
  - Precision agriculture companies  
  - Irrigation installer  
  - EU and National irrigation associations  
  - convince farmers  
  - change irrigation management  
  - Farmers  
  - FERTINNOWA and EU  
  - Finance the showcases  
  - Research  
  - Calibration of the system  
  - Adjustment in new crops  
  - Adjust new managements  
  - Advisor | - Demonstration (normal scheduling vs IRRIX)  
  - Technical doc and background information (key performance parameters)  
  - Need for knowledge transfer  
  - Designing web base program and integrated system | - Adapted to the particular conditions of each user  
  - Reduction of problems from the inadequate management of irrigation.  
  - Reduction of the cost (Saving water, reducing vegetative growth (pruning), maintained yield and fruit quality)  
  - Recommendations for the efficient management of water in crops adapted to the situation in each plot and to the development of the crop  
  - Relieve to the farmers from most of the tasks involved in acquiring data, scheduling, and supervising the application of efficient irrigation | - Personal relations with farmers: Word of mouth  
  - Knowledge advice to associations  
  - System can adapt its recommendations to each type of farmer, farm and technical knowledge. | - Individual:  
  - Technical managers  
  - Advisors  
  - Collectives:  
  - Agricultural cooperatives  
  - Irrigation associations |

<table>
<thead>
<tr>
<th>Key Resources</th>
<th>Key Activities</th>
<th>Value Proposition</th>
<th>Customer Relationships</th>
<th>Customer Segments</th>
</tr>
</thead>
</table>
| - Local supplier  
  - Adapt the system to different sensor (companies).  
  - Integration with irrigation programming systems in the market.  
  - Agronomic and computer support service  
  - Automatic alert communication system | - Demonstration (normal scheduling vs IRRIX)  
  - Technical doc and background information (key performance parameters)  
  - Need for knowledge transfer  
  - Designing web base program and integrated system | - Adapted to the particular conditions of each user  
  - Reduction of problems from the inadequate management of irrigation.  
  - Reduction of the cost (Saving water, reducing vegetative growth (pruning), maintained yield and fruit quality)  
  - Recommendations for the efficient management of water in crops adapted to the situation in each plot and to the development of the crop  
  - Relieve to the farmers from most of the tasks involved in acquiring data, scheduling, and supervising the application of efficient irrigation | - Personal relations with farmers: Word of mouth  
  - Knowledge advice to associations  
  - System can adapt its recommendations to each type of farmer, farm and technical knowledge. | - Individual:  
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  - Advisors  
  - Collectives:  
  - Agricultural cooperatives  
  - Irrigation associations |

<table>
<thead>
<tr>
<th>Cost Structure</th>
<th>Revenue Streams:</th>
</tr>
</thead>
</table>
| - Maintenance (technical dep)  
  - Marketing (local supplier)  
  - Research/development  
  - Integrate new crops / new irrigation techniques and sensors | - Maintenance of the service |
5 Summary

The main objective of FERTINNOWA is to create a meta-knowledge data base on innovative technologies and practices for fertigation and build a knowledge exchange platform involving various stakeholders. The project also wants to stimulate the implementation of the innovative technologies, being the main aim for WP4 of the project. After an inventory of the gaps (task 4.1) and an inventory of innovative technologies (task 4.2) in task 4.3, a business model (BUSINESS MODEL) was developed for three real innovations. The starting point for the business model development was a strong customer orientation, answering questions like what is the grower's pain, what does he expects to gain from the innovations and what relations do the growers prefer in the different stages to introduce and use new technology in his company. For this reason, the Business Model Canvas was used as a tool to fill in the business models for the three cases.

The main general conclusion was that the Canvas model is a very useful tool for business model development thanks to the structured and systematic set-up. In the defined 9 building blocks the main questions are raised and answered from different points of view but always with strong customer orientation. The three cases have learned that every innovation is asking for its own approach and that for every case the emphasis is on other things.

In the discussions in the workshops, it showed to be important to have clear in mind for whom we are writing this Business Model and who our customers are. For the three cases we have written the BUSINESS MODEL for the supplier of the technology, but it was clear that also other parties that want to stimulate the use of a technology (Research organisations, Government) can use such a model. Concerning the customer, we have chosen for the end-user, as also for other possible customers (advisors, other equipment suppliers or greenhouse building companies) the questions of the end user are central.

The information gathered in the FERTINNOWA project was very helpful for filling in the BUSINESS MODEL for all three cases. Especially the stakeholder interviews in WP2, the technology mapping and the benchmarking in WP3 gave a lot of insight in the customer's general pains and needs. The identification of gaps in task 4.1 was very helpful to make this more specific, especially for answering the main questions for the value proposition.

The value proposition showed to be the heart of the BUSINESS MODEL for all three cases, and together with the customer segmentation these blocks were most elaborated. Probably was the availability of much information gathered in other WP’s of the FERTINNOWA project – as above mentioned – one of the reasons for this.

There was a strong interaction between the different building blocks: A change in one building block has often effect on several other building blocks, so the development of the BUSINESS MODEL is a continuous self-developing process, and the content in the blocks of the Canvas Model did change several times. Besides, it was often difficult to distinguish between the different parts of the Canvas model. For example, the channels, are often strongly related to the
key partners, or more or less the same and also the customer relationships are linked to that, what sometimes resulted in repetition in the description.

1. Capacative Electro-dyalisis of Water Future

For the elaboration of the business model for the first case, the Capacative Electro-dyalisis (CED), it was difficult to fill in all the blocks already in detail, as the company and the technology are both still in development. The owner of the company left different possibilities open and sometimes the plan for the short term was different than for the long term. The value proposition for the ion-selective CED system was clear, but for Water Future coming up with a total water solution instead of a single technology a sustainable solution for the concentrates is a point of attention. From a technological point of view the geographical applicability was broad. Nevertheless information, based on the FERTINNOWA outcomes from different geographical areas showed that the NW area, and especially the Netherlands, Flanders and the North West part of France are the most interesting customer segments for the short term. The combination of soilless cropping system applying recirculation, the growth of sodium sensitive crops and legislation were important for this decision.

For the short term, different channels and key partners will be used. For creating awareness, different dissemination activities and on site demonstrations were key activities for the short term. As the company has not a large network in the horticulture yet, they want to make use of the network of their key partners, like the greenhouse builders and the research stations.

The two blocks related to the evaluation of the business case- the cost structure and the revenue streams – could not be elaborated in this stage. It is clear that this will change the coming period, depending on the role of Water Future.

The value proposition of the second case, the Sodium Removal Unit (SRU) of Optima Agrik, is comparable with that of the CED, as it is also focusing on selective sodium removal. Optima Agrik however, is more focusing at the specific technology itself – as Water Future wanted to sell more a total solution on the long term. Optima Agrik strives for complete reuse of the nutrients and if they succeed the problem of concentrated waste streams is solved. The savings in nutrient cost do cover an important part of the operational costs.

2. Sodium Removal Unit (SRU) from Optima Agrik

North West Europe showed being an interesting market segment. Therefore, OA sought cooperation with water technology supply companies in the Netherlands and Flanders. The SRU requires specific criteria regarding the sodium and chlorine concentration of the treated water and the crops’ nutrient demand. Bearing this in mind, OA opted to set up the business model for the treatment of recycled drain water. The SRU can as well be applied to treat fresh water, but competition with reversed osmosis proved to be hard. Optima Agrik strives for a personal approach with the customer to investigate the possibilities of the SRU for the farms’ situation and later to develop and fine-tune the installation.

To create awareness, Optima Agrik does not use much social media yet, but this is very recommended by the project partners of FERTINNOWA. Optima Agrik thinks the most powerful channel is the word of mouth and the participation in projects like FERTINNOWA. Optima Agrik considers developing a website in the future.
Most important key activities for the short term are the development of a working prototype and the further on-site demonstration.

3. **IRRIX DSS**

The third case concerns the introduction of Decision Support Systems in the horticulture. The effects of climate changes and the related extreme weather, result in stronger variations in temperature, rainfall, water requirements of crops, and the availability of water. A DSS meets the needs for a good irrigation management under the changing conditions. This is the added value of the IRRIX automatic irrigation system based at a DSS in combination with a sensors tool in the value proposition besides improvement of the irrigation management, resulting in saving water and fertilizers. Also, the savings in time for the grower were mentioned. However the main customer was the end-user, it can also be used and managed by advisors and supply companies, taking over part of the tasks of the grower, especially for those growers that are not familiar with ICT technologies. So these external parties are also relevant customers. The supplier or installer is the most important contact point between the system and the user. Also the farmer associations play an important role, facilitating recommendations and control strategies. For some countries, like Spain, the irrigation associations are very important, as they can decide on the needs and availability for water in a certain area.

For the IRRIX-DSS quite a lot of stakeholders were identified as key partners: Local suppliers, irrigation installers, companies selling irrigation programmes, irrigation associations and research institutes, as they can all have an important role in the introduction, sales, installation and use of the system. Demonstration of the system was also mentioned here as a key activity. It is important to have enough and good data available, also of the current used strategies, to calculate the effect in terms of savings and improved growth. The integration of a DSS in automatic irrigation system allows to adjust to the user, not the user adjusts to the system. This was shown to be crucial to support the incorporation of technologies (D4.1 "systems do not fit the user's needs"). The system with soil sensors learns in each irrigation season of the user and the characteristics of the irrigation system to improve its recommendations.
6 Annexes

6.1 Annex 1: Background information on Electro-dialysis

Working principle

The Water Future ion-selective desalination system makes use of the principle of electro-dialysis (ED). Electro-dialysis is a membrane separation process that is driven by an electrical potential difference over semi-permeable ion exchange membranes. A schematic representation of the working principle is shown in figure 4.1 [1].

An electric current migrates dissolved salt ions, including nitrates and sodium, through an Electro-dialysis stack consisting of alternating layers of cationic and anionic ion selective membranes.

Electrodialysis processes differ from distillation techniques and other membrane based processes (such as reverse osmosis (RO)) as only the dissolved salts are moved away from the feed stream instead of the water. Because only the ions are concentrated and not all the other components (and pollutants) Electro-dialysis offers the practical advantage of much higher feed recovery in many applications.

Operational conditions:

1. Risk of membrane fouling: Dispersed particles bad soluble salts (e.g. Ca salts), colloids, oils, fats and humus acids might be deposited on the membrane surfaces or in membrane pores so that the membrane’s performance is degraded. This process is called “membrane fouling”. Membrane fouling can cause severe flux decline and affect the quality of the water produced. Table 10 gives an non-exhaustive overview of possible pre-
treatments. Often a combination of coarse and fine filtration is used, especially for more polluted streams like surface water.

Table 9 technology/treatment

<table>
<thead>
<tr>
<th>Contaminant</th>
<th>Treatment/technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dispersed particles (10µm)</td>
<td>Rapid sand filtration (100-800µm), band filtration (5-10µm), Disc filtration (55-400µm), SAF-filtration Cloth filtration (5-10µm), Drum filtration (5-10µm), Microfiltration (0.1-10µm), Ultrafiltration (&lt;0.01µm).</td>
</tr>
<tr>
<td>Oils/fats</td>
<td>Coagulation or active carbon</td>
</tr>
<tr>
<td>Humic acids</td>
<td>Active carbon</td>
</tr>
</tbody>
</table>

Regular membrane cleaning with specific cleaning products (acids, bases...) may be necessary in a number of cases. The average life-span of ED membranes is between 5 and 7 years.

In most systems, periodically the direction of ion flow is reversed by reversing the polarity of the applied electric current. This will decrease the fouling of the membranes. This system is called EDR (ED Reversal). ED is used in large scale drinking water production for over 60 years. Also for the treatment of different industrial (waste) water streams ED® is applied for a long.

2. As a general rule of thumb, in practice, the limit of 3000 ppm of dissolved substances is regarded as the line between cost effective treatment via reverse osmosis and ED: Thus, ED is recommended if the concentration of dissolved substances is lower than 3000 ppm and reverse osmosis if above 3000 ppm.

3. Another argument in favour of ED could be the need for high feed recovery.

4. ED has inherent limitations, working best at removing low molecular weight ionic components from a feed stream. Non-charged, higher molecular weight, and less mobile ionic species will not typically be significantly removed. Also, in contrast to Reversed osmosis, ED becomes less economical when extremely low salt concentrations in the product are required. Consequently, comparatively large membrane areas are required to satisfy capacity requirements for low concentration (and sparingly conductive) feed solutions.

Advantages:

2. High feed recovery (90-95%), only a limited waste stream (5-10%) is produced.

Disadvantages:

1. Concentrate containing nitrate (NO3- ) and chlorine (Cl-). In case drain water is treated by the ED, the concentration of NO3- might exceed the allowed discharge concentration (max. 50mg NO3/l). In this case, the concentrate will have to be treated.
2. The discharge of the concentrate resulting from ED processes is restricted in a number of countries, what can be a limitation or extra cost factor.
ED is used is applied for large-scale drinking water production for over 60 years. Also for the treatment of different industrial wastewater streams ED is used for a longer period. More recently, the horticultural sector gained interest for this technology as it allows semi-selective removal of sodium. A picture of the system of Water Future, developed for application in the horticulture, is given below.

![Figure 16 Picture of a CED system (Water Future)]
### 6.2 Annex 2: Working principle of the SRU unit:

Optima Agrik’s Sodium Removal Unit uses a combination of the principles of two very common uses of ion exchange; water desalination and water softening. In the process, positively charged ions are absorbed onto a cation resin and negatively charged ions are absorbed onto an anion resin.

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**Figure 17 Working principle of the SRU unit**

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Since only sodium is to be removed from the drain water only a cation resin is used. The process can be divided into three steps:

- **Step 1**
  
  In this step the sodium is separated from all the negatively charged nutrients. The drain water is pumped through a column containing the cation exchange resin in the hydrogen form. The sodium (Na), together with all the other cations, is removed from the water by the exchange that takes place between the resin and the water; the cations get absorbed onto the resin by replacing the hydrogen which is now dissolved in the water. The result is a solution with a low pH which, after being neutralised with potassium hydroxide (KOH), can be re-used in the greenhouse. In the process 100% of the nitrates (NO₃) and phosphates (PO₄) are recovered. The KOH used for neutralisation is commonly used in greenhouses and the solution is therefore safe to use in the greenhouse since it contains only compounds already used in the greenhouse. As soon as the resin is saturated, the flow of the drain water through the resin is stopped.

- **Step 2**
  
  In this step the absorbed sodium is separated from the positively charged nutrients by pumping a KCl solution through the cation resin. The resin has a higher selectivity for K than Na which drives the reaction to some extend towards the replacement of Na by K on the resin. Excess K is needed to ensure sufficient removal of Na. The volume of the chloride-concentrate (NaCl) is typically only 5% of the volume of drain water treated in Step 1.

- **Step 3**
  
  In this step the positively charged nutrients are recovered by pumping a nitric acid (HNO₃) solution through the resin to recover the cationic nutrients as a nitrate mixture for re-use in the greenhouse. This step also regenerates the resin for the next cycle. The pH of this solution is also very low because of the excess acid needed to ensure sufficient regeneration of the resin. This solution is neutralised with the same KOH used in Step 1.
6.3 Annex 3. Alternative (desalination) technologies to Electro dialysis

Table 101 Alternative (desalination) technologies to Electro dialysis

<table>
<thead>
<tr>
<th>Technology</th>
<th>Description</th>
<th>Strengths</th>
<th>Weakness</th>
<th>TRL(^{19})</th>
<th>Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reverse Osmosis</td>
<td>Pressure driven membrane process</td>
<td>Proven Technology Costs</td>
<td>No selectivity</td>
<td>8 (for water production)</td>
<td>0.5-3 €/m³, depending on scale</td>
</tr>
<tr>
<td>Nanofiltration</td>
<td>Pressure driven membrane process</td>
<td>Proven technology, Selective removal of multivalent ions</td>
<td>No removal of mono-valent ions, Fouling, Concentrates</td>
<td>8</td>
<td>0.2-2 €/m³, depending on the scale</td>
</tr>
<tr>
<td>Capacitive deionisation</td>
<td>Electricity Driven process, use of capacitive electrodes</td>
<td>No chemicals or antiscalcing products required, Recovery: 80-90%</td>
<td>Optimisation of electrodes needed More efficient for low salinity waters</td>
<td>8 (for ground water)</td>
<td>1-5 €/m³</td>
</tr>
<tr>
<td>(Modified) Ion exchange, SRU</td>
<td>Use of Resins to exchange ions</td>
<td>Production of fertilisers, Lower fouling potential, Semi-selective removal of sodium</td>
<td>Rather high capacity needed. No figures from practice</td>
<td>6-7 pilot study on drain/ purge water</td>
<td>Not clear yet, see chapter on SRU</td>
</tr>
<tr>
<td>(Membrane) distillation</td>
<td>Temperature driven</td>
<td>Also disinfection of the water</td>
<td>Fouling, plugging not selective only concentration, Concentrates</td>
<td>6-7 only pilot available</td>
<td>1-2 €/m³</td>
</tr>
<tr>
<td>Forward Osmosis</td>
<td>Osmotic pressure driven membrane process</td>
<td>High concentration possible</td>
<td>Multi steps for cleaning water, not selective only concentration, Less Fouling risks</td>
<td>6</td>
<td>?</td>
</tr>
<tr>
<td>Electro-dialyses</td>
<td>Electricity driven membrane process</td>
<td>Partial selectively</td>
<td>No ppp removed salts removed,</td>
<td>6-7 for agro applications</td>
<td>1-5 €/ m³</td>
</tr>
</tbody>
</table>

\(^{19}\) Technology Readiness Level (See Annex 4).

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6.4 Annex 4. Technology readiness levels (TRL)

Where a topic description refers to a TRL, the following definitions apply, according to the EU:

- TRL 1 – basic principles observed
- TRL 2 – technology concept formulated
- TRL 3 – experimental proof of concept
- TRL 4 – technology validated in lab
- TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies)
- TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies)
- TRL 7 – system prototype demonstration in operational environment
- TRL 8 – system complete and qualified
- TRL 9 – actual system proven in operational environment (competitive manufacturing in the case of key enabling technologies; or in space)