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Practical Feasibility Final Report

D 2.2.2 Overall practical feasibility and best practices to be used in other sites.

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PRACTICAL FEASIBILITY FINAL REPORT

D 2.2.2 Overall practical feasibility and best practices to be used in other sites

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The content of this report summarizes the conclusions achieved on the NEREUS practical feasibility workshop and on the *D 2.2.1 Joint practical feasibility report* (van Schaik et al., 2021).

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1 Executive summary

This report, *Deliverable D 2.2.2*, summarizes the findings among pilot partners, regarding the overall practical feasibility and best practices, on resource recovery and reuse, to be used in other sites, outside and beyond the NEREUS project. The information presented here was mostly gathered during the *NEREUS Practical Feasibility Workshop*, hosted by HZ University of Applied Sciences, which is fully covered in the *D 2.2.1 Joint practical feasibility* report (van Schaik et al., 2021).

In order to decide the best practices, the recovery processes were analyzed on feasibility according to different criteria, such as: economic, recovery percentage of product of interest, social and environmental impact. The conclusions were then made based upon analysis of the product being recovered, the influent stream type and the treatment train used by the partners.

The NEREUS pilot partners (PPs) Agglomeration of Saint-Omer (CAPSO), DuCoop CVBA, Evides Industrial Water B.V, Southern Water Services Ltd and water-link were responsible for running pilot plants and gathering data and information to be later used for establishing the practical feasibility. These finding were then discussed between the PPs and the remaining NEREUS consortium; VITO NV, HZ University of Applied Sciences and University of Portsmouth Higher Education Corporation. Hence, the conclusions concerning the best practices for resource recovery are presented and discussed in this report.

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2 Methods

In order to draw conclusions concerning the feasibility of recovering valuable resources from wastewater, the five pilot plants within the NEREUS project, tested different treatment trains between them. Therefore, this section presents a description on the products aimed to be recovered by each PP and the criteria used to assess the feasibility of these processes and technologies involved.

2.1 Pilot plants

Among others, the NEREUS consortium is composed of five companies that are responsible for running a pilot plant each for resource recovery from wastewater. Table 1 presents each pilot partner, along with their influent stream type and location of the plant.

Table 1 - Products recovered at each pilot plant

Pilot partner	Influent stream	Plant location	Recovered product
Agglomeration of Saint-Omer (CAPSO)	Sludge from centrifuge	Saint-Omer, FR	• Dried sludge for soil conditioning
DuCoop CVBA	Grey water	Ghent, BE	• Energy (heat) • Water (process)
Evides Industry Water B.V.	Urban wastewater	1st: Rotterdam, NL [a] 2nd: Delft, NL [a]	• Energy (bio-methane) • Water • Nutrients (N & P)[b], cellulose
Southern Water Services Ltd	Urban wastewater	Fareham, UK	• Nutrients (N & P)[b]
water-link	Grey water	Antwerp, BE	• Water (drinking)

[a] Evides initially operated their pilot plant in Rotterdam, however, it was later moved to a second location near Delft.
[b] N: nitrogen, P: phosphorus.

As seen in Table 1, different types of products were aimed to be recovered; covering water, energy and other types of resources (e.g. nutrients), from different types of wastewater influent stream. Besides that, the pilot plants were located in different parts of the 2 Seas[1] region: France, Belgium, the Netherlands and the United Kingdom. All of this diversity enabled the testing of different technologies, treatment trains and operational conditions, which is an important key for best practices development.

The NEREUS project ran from October 2017 to December 2021, and during that time, the pilot plants were designed, operated and optimized. All information gathered in this period facilitated the conclusion concerning the feasibility of transforming wastewater into valuable products to be reused.

[1] 2 Seas: Covers coastal areas of England, France, Belgium (Flanders) and the Netherlands which are connected by the Channel and the North Sea (Interreg 2 Seas, n.d.)

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2.2 Feasibility Criteria

In order to analyse the performance and feasibility of the technologies used, and also the complete treatment train, some criteria had to be defined and chosen. An extensive list of criteria to be used when completing a feasibility study was created earlier in the NEREUS project under activity A2.1: Template for feasibility studies. During this activity, deliverables D2.1.1: List of topics for feasibility study and D2.1.2: Quality inventory and technology quick scan, were combined to produce D2.1.3: General usable template feasibility study (McAteer & van Schaik, 2017a, 2017b; van Schaik & McAteer, 2017). Figures 1 and 2 below show the thought process behind executing a feasibility study and which broader criteria categories should be taken into account.

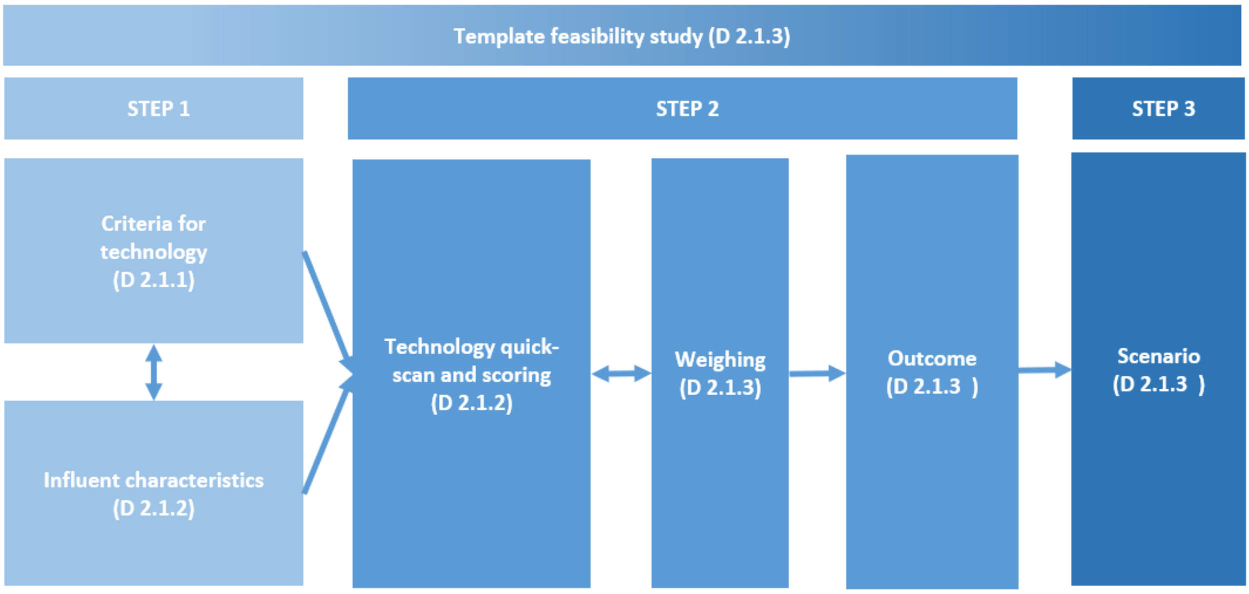

Figure 1 - Overview of steps taken when designing a feasibility study.

Reproduced from “NEREUS Deliverable D 2.1.3 : General usable template feasibility study” by McAteer & van Schaik, 2017b.

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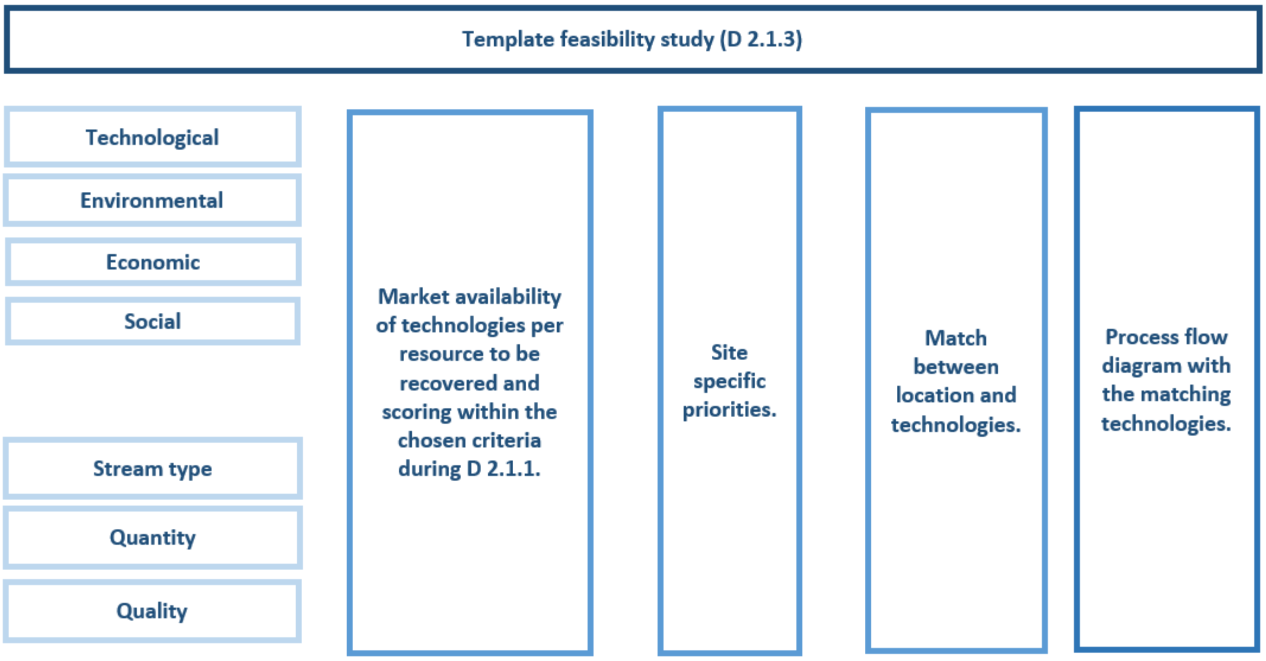

Figure 2 - Overview of criteria and site specific elements contributing to a feasibility study

Reproduced from "NEREUS Deliverable D 2.1.3 : General usable template feasibility study" by McAteer & van Schaik, 2017b.

As can be seen in Figure 2, the criteria upon which a technology can be assessed can be grouped into the categories; technological, environmental, economic and social. Some examples of criteria that fall into such categories include; CAPEX and OPEX (economic), % recovered product (technological), CO_2 footprint (environmental) and noise and odour pollution (social). The relationships between these categories and site specific aspects is visually represented in Figure 3 below.

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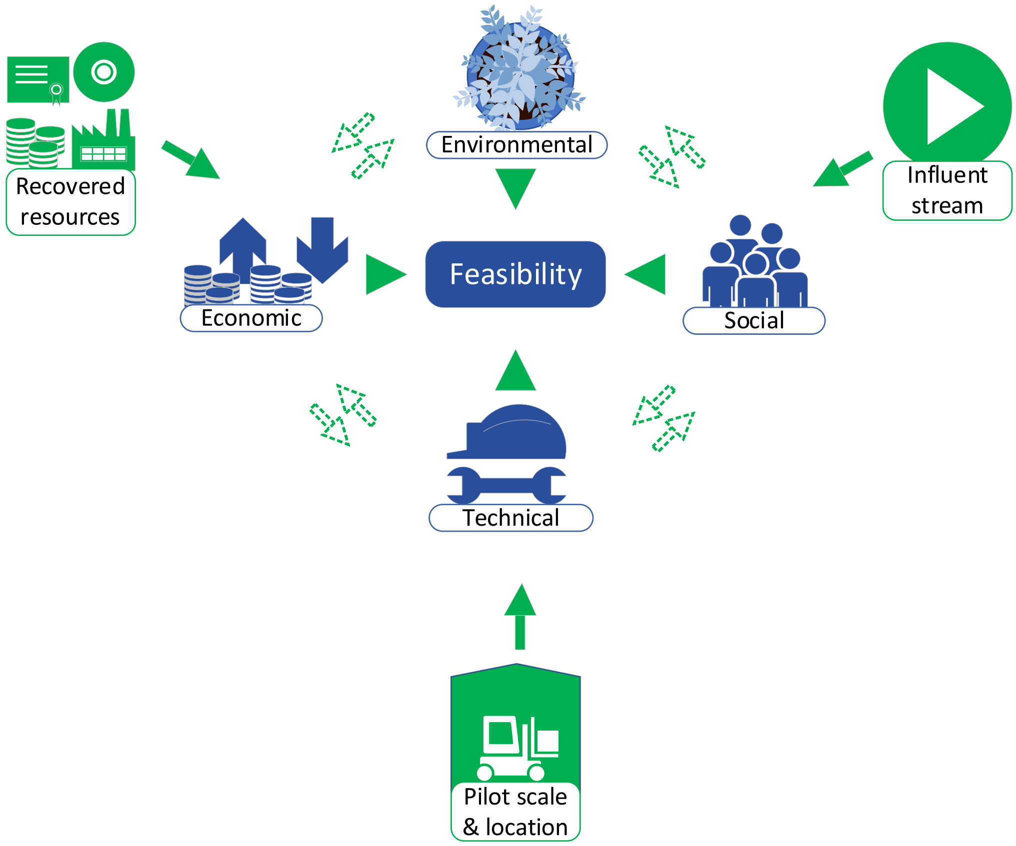

Figure 3 - Feasibility categories and site specific criteria

As not all pilot partners were focussed on recovering the same products or using the same technologies, their site specific feasibility studies were not identical. In order to ensure that they could still be compared with similarities and differences being analysed, HZ University of Applied Sciences drew up a template for each pilot partner to fill in. An example of this template can be found in Appendix I.

The templates were partly site specific and partly generic. The site specific part asked for the main issues experienced when using each technology during steady-state operation and if relevant, the solution found to the issues, under the question; *what worked and what not?* per resource recovered. The generic part of the template asked for the lessons learned during operation per resource recovered under general categories. The categories used in the templates were chosen as most influential based on experience from discussion with pilot partners during the technical meetings and workshops held over the course of the NEREUS project. These categories can be seen in Figure 3.

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3 Evaluation

In this section, the evaluation of resource recovery feasibility is presented for water, energy, and other types of resources (e.g. nutrients). Per type of resource, an assessment of the technologies used by the partners, in their treatment train, is presented in the form of a table containing a color coded overall conclusion. Table 2 presents the color code definition used.

Table 2 - Color code definition

Color	Definition
Green	• No issues at all or solvable issues • Achieved desired recovery (%) or final product quality • Does not require (much) chemical and/or energy use
Yellow	• Solvable issues and non-solvable issues • Achieved (or almost) desired recovery (%) or final product quality • Requires chemical and/or energy use
Red	• Too many non-solvable issues • Did not achieve desired end product • Requires chemical and/or energy use

As there is more than one aspect being analyzed in the color definition, the final result is a combination of all gathered conclusions concerning the criteria being evaluated.

Along with the feasibility evaluation, the best practices, concluded by the partners are also discussed per resource. These were defined according to what they've learned throughout the project, concerning the influent stream, process sequence, etc., as explained in *section 2.2*.

It should be noted that all evaluations and conclusions presented in this report only relate to the experiences of the pilot partners during operation of their pilot within the project timeline. It could be that the technologies used and evaluated perform differently in different pilot circumstances.

3.1 Resource recovery feasibility

This resource category explores the feasibility of recovering two types of nutrients; phosphorus and nitrogen, (dried) sludge and also a carbon source (cellulose).

3.1.1 Phosphorus

Phosphorus recovery was tested by Southern Water, in the form of struvite and calcium phosphate ($Ca_3(PO_4)_2$). Their main finding was that the interruption of the plant (the plant had to re-start everyday), caused the pellets formed to be small and fragile. Besides that, the location of the plant plays a major role, this is supported by the fact that heavy metals were found in the pellets, which is believed to come from a nearby factory. This is summarized in Table 3, along with an evaluation of the technologies used during the process:

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Table 3 - Evaluation of technologies used for phosphorus recovery

	Stripping (for $Ca_3(PO_4)_2$)	Calcium phosphate precipitation	Struvite precipitation	Filter
Streams [a]	• Centrate • Digestate	• Centrate • Digestate	• Centrate • Digestate	
Partners involved	• Southern Water	• Southern Water	• Southern Water	• Southern Water
Remarks and conditions [b]	-	• Unit should be run in 24/7 operation. Interruptions caused small pellet formation	• Unit should be run in 24/7 operation. Interruptions caused small pellet formation	-
Environment [a]	• Energy required	• Energy required • Chemicals required	• Energy required • Chemicals required	• Some energy required
Expected recovery/quality [a]	-	• Presence of undesired compound • > 80% recovery	• Risk of contamination • > 80% recovery	-
Achieved recovery/quality [b]	-	• 95% P removal • 40-45% recovery • Other metals: Al, Fe, Mg, Zn & Ni [c]	• 95% P removal • 30% recovery • Other metals: Al, Fe, Cr & Zn [c]	-
Overall conclusion				

Note. The table presents information regarding the technologies used for phosphorus recovery as struvite and $Ca_3(PO_4)_2$.

[a] Adapted from : "Technology quick-scan", *NEREUS Deliverable D 2.1.2*, by McAteer & van Schaik, 2017.

[b] Adapted from presentation shared by Southern Water during the *NEREUS Practical Feasibility Workshop* (Randall & Hossain, 2021).

[c] Al: aluminium, Fe: iron, Mg: magnesium, Zn: Zinc, Ni: nickel, Cr: chromium.

Therefore, Southern Water concluded that although having a good process sequence, the recovery was not economically feasible. The main reasons for that, which would require changes, are the size of the plant that should be of at least 150,000 PE and that the process should not be operated manually, as the formed pellet is not satisfactory.

3.1.2 Nitrogen

The other nutrient recovered was nitrogen, tested by Evides, in the form of algae pigment. As seen in Table 4, the process sequence was satisfactory, however, requires energy and chemicals, especially heat to grow the algae, having both economic and environmental impact.

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Table 4 - Evaluation of technologies used for nitrogen recovery

	Nanofiltration	Reverse osmosis	Algae culture
Streams [a]	• Grey water • Effluent from aerobic treatment	• Grey water • Effluent from aerobic treatment	• Effluent loaded with nitrogen
Partners involved	• Evides	• Evides	• Evides
Remarks and conditions [b]	• Used to separate N from the rest of the stream (permeate)	• Used to separate N from water (concentrate)	• Using mixotroph can help on algae growth • Getting the pigment out is difficult
Environment [a]	• Energy required • Chemicals required	• Energy required • Chemicals required	• Energy required
Expected recovery/quality [a]	-	-	-
Achieved recovery/quality	-	-	n.a.[c]
Overall conclusion			

Note. The table presents information regarding the technologies used for nitrogen recovery as algae pigment.
[a] Adapted from: "Technology quick-scan", *NEREUS Deliverable D 2.1.2*, by McAteer & van Schaik, 2017.
[b] Adapted from presentation shared by Evides during the *NEREUS Practical Feasibility Workshop* (Steenbakker & van den Brink, 2021).
[c] not available. The achieved recovery was not available by the end of this report.

According to Steenbakker & van den Brink, 2021, the pigment produced by the algae is valuable, but hard to extract, this would need to be optimized in order to be economically feasible. Along with this, the scale should be larger and this is highly dependent on the quality and quantity of the produced pigment.

3.1.3 Dried sludge

Table 5 contains the evaluation for (dried) sludge recovery for soil conditioning, tested by CAPSO. They believe the process to be feasible, in which they've managed to achieve the siccity, that is, the dryness level, regulation (in France). The screw conveyor used allows lower maintenance, which is financially beneficial, but optimization tests should be performed to reduce the amount of lime dosing, as it is expensive.

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Table 5 - Evaluation of technologies used for sludge recovery

	Conveyor	Lime dosing
Streams	• Sludge from centrifuge	• Sludge from centrifuge
Partners involved	• CAPSO	• CAPSO
Remarks and conditions		• Final product application depends on regulation
Environment	• Energy required	• Chemicals required
Expected recovery/quality	-	• Siccity of sludge ≥ 30% (regulation in France)
Achieved recovery/quality	-	Siccity of sludge > 33%
Overall conclusion		

Note. The table presents information regarding the technologies used for sludge drying, provided by CAPSO, during the *NEREUS Practical Feasibility Workshop* (Courouble, 2021).

According to CAPSO, the process and storage can be done anywhere, as long as located more than 100m from houses, and with the right dosage of lime being used to kill bacteria and reduce odours. The dried sludge also enables easier transportation.

3.1.4 Cellulose

Table 6 contains the analysis for carbon recovery, as cellulose, performed by Evides. It was concluded that this process can be feasible in both pilot and full scale.

Table 6 - Evaluation of technologies used for cellulose recovery

	Fine Sieves	Enzymatic conversion
Streams [a]	• Black water • Domestic wastewater	• Screenings of black/domestic wastewater
Partners involved	• Evides	• Evides
Remarks and conditions [b]	-	-
Environment [a]	• Some chemicals required	• Energy required
Expected recovery/quality [a]	• > 80% recovery	-
Achieved recovery/quality	-	n.a.[c]
Overall conclusion		

Note. The table presents information regarding the technologies used for carbon source recovery (cellulose).

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[a] Adapted from : "Technology quick-scan", *NEREUS Deliverable D 2.1.2*, by McAteer & van Schaik, 2017.
[b] Adapted from presentation shared by Evides during the *NEREUS Practical Feasibility Workshop* (Steenbakker & van den Brink, 2021).
[c] not available. The achieved recovery was not available by the end of this report.

3.2 Water recovery feasibility

Water recovery was performed by DuCoop, Evides and water-link, therefore, Tables 7 and 8 present an evaluation of the technologies used in all three treatment trains.

Table 7 - Evaluation of technologies used for water recovery I

	Sieves	**MBR-UF**	**Fe Electro-coagulation**	**Coagulation ($FeCl_3$)**
Streams [a]	• Domestic wastewater	• Domestic wastewater	• Domestic wastewater	• Grey water • Effluent from aerobic treatment
Partners involved	• Evides • water-link	• DuCoop	• Evides	• Evides
Remarks and conditions [b]	• Monitor water loss	• A lot of chemicals needed for denitrification, extra P removal and membrane cleaning	• Newer technology (more challenges): if placed at beginning of train, can prevent full train trials	• Control the sludge blanket to prevent it from flushing out
Environment [a]		• Energy required • Chemicals required	• Energy required	• Chemicals required
Expected recovery/quality [a]	-	-	-	-
Achieved recovery/quality [b]	-	-	-	-
Overall conclusion				

Note. The table presents information regarding the technologies used for water recovery (in different types).
[a] Adapted from : "Technology quick-scan", *NEREUS Deliverable D 2.1.2*, by McAteer & van Schaik, 2017.
[b] Adapted from presentation shared by DuCoop, Evides and water-link during the *NEREUS Practical Feasibility Workshop* (Bossaerts, 2021; Seuntjens, 2021; Steenbakker & van den Brink, 2021).

Table 8 - Evaluation of technologies used for water recovery II

	Nanofiltration	**Reverse Osmosis**	**Ozon -UV**
Streams [a]	• Grey water • Effluent from aerobic treatment	• Grey water • Effluent from aerobic treatment	• Grey water • Effluent from aerobic treatment
Partners involved	• Evides	• Evides • water-link	• water-link

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	Nanofiltration	Reverse Osmosis	Ozon -UV
Remarks and conditions [b]	• Might need prior biological treatment to achieve quality and prevent fouling	• Might need prior biological treatment to achieve quality and prevent fouling	• Might need prior biological treatment to achieve quality
Environment [a]	• Energy and chemicals required	• Energy and chemicals required	• Some chemicals required
Expected recovery/quality [a]	• High purity • 60-80 % recovery	• High purity • 60-80 % recovery	• High purity • 60-80 % recovery
Achieved recovery/quality [b]	• 75% recovery achieved	• 75% recovery achieved	• Achieved removal of virus, bacteria and odour
Overall feasibility			

Note. This table is a continuation of Table 7, and presents information regarding the technologies used for water recovery (in different water types).

[a] Adapted from : "Technology quick-scan", *NEREUS Deliverable D 2.1.2*, by McAteer & van Schaik, 2017.

[b] Adapted from presentation shared by Evides and water-link during the *NEREUS Practical Feasibility Workshop* (Bossaerts, 2021; Steenbakker & van den Brink, 2021).

An important remark from these partners is the technical complexity of the influent; it directly influences the process sequence and the quality of the end product. According to water-link, raw water sources present a high diversity and variability in composition, making it difficult to define a stable solution. This challenge was also pointed out by Evides and DuCoop, in which was concluded that the collection of dark grey water from kitchen into the influent and also using domestic wastewater, as starting point, bring more polluted water into the system.

Therefore, they've observed the importance of having a biological process in the train to lower organic matter content, that could prevent water from achieving the desired quality and also cause membrane biological fouling.

3.3 Energy recovery feasibility

Energy recovery was performed by DuCoop and Evides, in the form of heat and biogas, respectively. This evaluation is presented in Table 9.

Table 9 - Evaluation of technologies used for energy recovery

Aspects	Anaerobic digestion (methane)	Heat exchanger
Streams [a, b]	• Sludge • Biomass (algae)	• Purified wastewater
Partners involved	• Evides	• DuCoop
Remarks and conditions [b]	• Algae: achieved little production of methane	• Smart control: match heat recovery to the time it is needed

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Aspects	**Anaerobic digestion (methane)**	**Heat exchanger**
Environment [a]	• Energy recovery	• Energy recovery
Expected recovery/quality [a]	• > 80% recovery	• > 80% recovery
Achieved recovery/quality [b]	n.a.[c]	n.a.[c]
Overall feasibility		

Note. The table presents information regarding the technologies used for energy recovery as biogas (methane) and heat.

[a] Adapted from : "Technology quick-scan", *NEREUS Deliverable D 2.1.2*, by McAteer & van Schaik, 2017.

[b] Adapted from presentation shared by DuCoop and Evides during the *NEREUS Practical Feasibility Workshop* (Seuntjens, 2021; Steenbakker & van den Brink, 2021).

[c] not available. The achieved recovery was not available by the end of this report.

According to Evides, when testing the anaerobic digestion of algae, the production of methane (biogas) was very low. Therefore, they carried on with digesting only the sludge from the coagulation unit, which can be feasibly applied for both pilot and full scale.

An important remark from DuCoop is about having a smart control of the whole process, in order to be able to match the time when heat is recovered and when it is needed. Therefore, the process should be applied close to the treatment plant and to the end user, to avoid heat losses.

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4 Conclusion

The conclusion was made per resource and per influent stream (grey water and urban wastewater), representing the streams treated by the partners. The same color code described in *section 3* was used, concerning the feasibility of the recovery process. The grey color was included to account for processes that were not tested within the NEREUS project but which were analyzed for their possible feasibility, accordingly to the conclusions achieved in this report.

Tables 10, 11 and 12 contain the conclusions concerning the recovery feasibility of resources, water and energy, respectively.

Table 10 - Resource recovery feasibility from different streams

	Recovered resource			
	Nitrogen	Phosphorus	Sludge	Cellulose
Grey water	**No**	**Conditional**	**Conditional**	**No**
Urban wastewater	**Yes**	**Conditional**	**Yes**	**Yes**
Scale	200,000 PE	200,000 PE	200,000 PE	200,000 PE
Location	Away from city centers (no social impacts)	Away from city centers (no social impacts)	Anywhere > 100 m from houses (regulation in France)	Away from city centers (no social impacts)
Operation & maintenance	Algae: Needs continuous care Struvite: Automated and operated continuously	Struvite and $Ca_3(PO_4)_2$: Automated and operated continuously	Low maintenance (with screw conveyor)	Low maintenance and does not require continues care during operation

(Courouble, 2021; Randall & Hossain, 2021; Steenbakker & van den Brink, 2021; van Schaik et al., 2021)

Although not being tested within the NEREUS project, it was concluded that recovering the resources, presented in Table 10, are difficult/not feasible from grey water. The reason for that is that this type of stream has a low concentration of nutrients and biomass. Phosphorus recovery could be tested if it was previously concentrated, in order to see if the quality and quantity enables this process. For sludge, the achieved conclusion was that it might be worthwhile if the grey water is treated biologically, and the produced sludge from this process is then treated for achieving the appropriate quality and siccity.

Therefore, urban wastewater offers better conditions for recovering these types of resources, due to its characteristics. Phosphorus is listed as conditional, because, according to partners, it should be recovered in a large scale, as economic and technical feasibility are the main issues.

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Table 11 - Water recovery feasibility from different streams

	Recovered water		
	Drinking	Irrigation	Process
Grey water	**Conditional**	**Conditional**	**Yes**
Scale	200 PE	-	200 PE
Location	Away from city centers (no social impacts) or underground	Away from city centers (no social impacts) or underground	Away from city centers (no social impacts) or underground
Operation & maintenance	Continuous maintenance and operation.	Continuous maintenance and operation.	Continuous maintenance and operation.
Urban wastewater	**No**	**Conditional**	**Conditional**
Scale	-	200,000 PE	200,000 PE
Location	-	Away from city centers (no social impacts)	Away from city centers (no social impacts)
Operation & maintenance	-	Continuous maintenance and operation.	Continuous maintenance and operation.

(Bossaerts, 2021; Seuntjens, 2021; Steenbakker & van den Brink, 2021; van Schaik et al., 2021)

As discussed in *section 3.2*, the influent's characteristic diversity is considered one of the main issues when recovering water, being highly important for determining the process sequence and the end product quality.

Drinking water was considered practical only if the process is optimized and controlled well, by investing in operation and maintenance (O&M) automation. Also, according to water-link, a study to define a scale size break-even point is necessary, in order to be economically feasible. Due to these difficulties that are already present for grey water, the water recovery from urban wastewater is listed as "no" in the table, as it is more polluted and harder to treat.

Process water from urban wastewater and irrigation from both streams were listed as "conditional". It was concluded that the treatment plant should be away from city centers and on a large scale. According to partners, it needs a pathogen control, which is unfeasible at small scale, as well as the costs related to O&M.

Table 12 - Energy recovery feasibility from different streams

	Recovered energy	
Aspects	Heat	Biogas
Grey water	**Yes**	**Conditional**
Scale	200 PE	-
Location	Close to the wastewater treatment plant and user to avoid heat losses	-

	Recovered energy	
Aspects	Heat	Biogas
Urban wastewater	**Conditional**	**Yes**
Scale	-	200,000 PE
Location	-	Close to the wastewater treatment plant

(Seuntjens, 2021; Steenbakker & van den Brink, 2021; van Schaik et al., 2021)

According to DuCoop, thermal energy has a practical recovery from grey water, as long as it is processed with treated wastewater, in order to reduce O&M costs, and also if it is located close to the plant and end user. Therefore, this type of energy could be recovered from urban wastewater only if the treated water achieved a good quality prior entering the pump/heat exchanger system, due to O&M, as explained before.

Energy recovery from urban wastewater in the form of biogas, was considered feasible due to the high sludge/biomass production during its treatment. However, recovering biogas from grey water would require this type of stream being treated biologically, so that the sludge/organic matter could be digested. For this reason, this should be applicable at large scale or with a collection of biomass from multiple plants.

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5 References

Bossaerts, W. (Waterlink). (2021). *NEREUS Practical feasibility workshop - Water-link presentation*. Waterlink.

Courouble, S. (CAPSO). (2021). *NEREUS Practical feasibility workshop - CAPSO presentation*. CAPSO - COMMUNAUTÉ D'AGGLOMÉRATION DU PAYS DE SAINT-OMER.

Interreg. (n.d.). *Programme area*. Interreg 2 Seas. Retrieved July 14, 2021, from https://www.interreg2seas.eu/en/content/programme-area

McAteer, E., & van Schaik, M. (2017a). *NEREUS Deliverable D 2.1.2. Quality inventory and technology quick scan*. HZ University of Applied Sciences.

McAteer, E., & van Schaik, M. (2017b). *NEREUS Deliverable D 2.1.3. General usable template feasibility study*. HZ University of Applied Sciences.

Randall, C. (Southern W., & Hossain, A. (Southern W. (2021). *NEREUS Practical feasibility workshop - Southern Water presentation*. Southern Water.

Seuntjens, D. (DuCoop). (2021). *NEREUS Practical feasibility workshop - DuCoop presentation*. DuCoop VBA.

Steenbakker, T. (Evides I., & van den Brink, P. (Evides I. (2021). *NEREUS Practical feasibility workshop - Evides presentation*. Evides Industriewater.

van Schaik, M., & McAteer, E. (2017). *NEREUS Deliverable D2.1.1. List of topics for feasibility study*. HZ University of Applied Sciences.

van Schaik, M., Mendonça, I., & McAteer, E. (2021). *NEREUS Joint Practical Feasibility Workshop Report*. HZ University of Applied Sciences.

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Appendix

I – Templates for pilot plant practical feasibility

Practical feasibility

What worked and what not for "*resource type*" recovery?

Processes	Process 1	Process 2	Process 3
Main issues throughout steady-state operation			
Solution			

Colour code:

Too many non solvable issues	Solvable and non solvable issues	Solvable or no issues at all

1

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Practical feasibility

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Lessons learned

Resource	Influent	Process sequence	Optimum scale	Location of the pilot plant	Operations & Maintenance	Recovered resource	Other
Resource type							
Other							

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