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North-West Europe
Green WIN
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WPT1 A3 Pumping technologies and renewable energy

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Content

1 Introduction

This report contains case studies that show Reduction of energy consumption and CO2 emissions in pumping operations. The report is a deliverable in work package 1 of the project. In chapter 2 an overview of this work package is given. Chapter 3 shortly describes the case studies that have been collected from the various partners:

- Canal and River Trust
- Ministerie van Infrastructuur en Waterstaat-Rijkswaterstaat
- Waterways Ireland
- Voies Navigables de France
- Vlaamse Landmaatschappij

Chapter 4 shows the detailed factsheets of each case study. These factsheets consist of the following parts:

- Context
- Aim of the experience
- Description of the experience
- Summary of measures
- Estimate of CO2 reduction and other outcomes

The case studies can be found in the Green Pumping Toolkit (GPT).

Images with terminology will be inserted here.

2 Description work package

Context and problem:

Water Management Organizations (WMO) produce high CO_2 emissions caused by carbon 'heavy' pump technology in use, which typically accounts for up to 60% of WMO's total emissions. The technical specifications of such machinery and systems have not focused sufficiently on energy saving and carbon reduction, but rather on short term cost efficiency and on a "need-to-replace" based investment programme.

The Green WIN project aims to use trials of **low carbon water pumping technologies, systems and processes** to show WMO's how they can significantly reduce their energy consumption and CO_2 emissions by installing more efficient pumping technologies.

General method:

Green WIN will facilitate collaboration and pooling of SME's and WMO's knowledge and resources to build a critical mass to drive the change needed to adopt new technology and systems that can deliver long term carbon reduction through higher efficiencies.

All partners review their current practice and scope for green improvements, researching available pumping technology in NWE and evaluating emerging technologies and existing R&D in this field. They will assess opportunities to improve operational and management techniques and whether improved 'smarter' configurations or optimised pump management can deliver greener operations and maximize use of RE.

Framework

Reduction of energy use and CO_2 emission asks for more than assessment of the performance of individual pumps only. Pumps function in a system built up by several hierarchical levels:

- Pump level
- Plant or pumping station level
- System level (canal / water system)

When trying to reach the overall aim to minimise CO_2 emission, performance optimisation and improvement at these three levels involve different aspects.

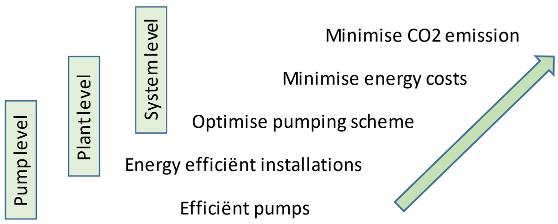

Figure 1:System levels for improvement

Pump level

At the pump level, pump characteristics are important in relation to energy consumption and CO2 emission: type, working range, drive (diesel, electric …) and energy supply (electricity, diesel).

Pumps can be optimized, taking into account pump types, their pump characteristics rated to the working rand. Drives have to be energy efficient. The energy source determines the CO2 production.

Plant level / pumping station

At plant level a system consists of (often) multiple pumps, connecting pipework, debris gratings and such. Installations for operating the pumps consisting of hardware and software. Sensors to feed the operation and control of the installations and connection with a control centre. All these installation are placed in a building with climate control, access- and surveillance facilities. Facilities for maintenance and operations personal.

At this level a more complex set aspects parameters comes into sight. Not limitative cooperation of multiple pumps taking into account their working ranges. Energy consumption of building related installations like climate control form are often important too.

System level (canal/water system)

At system level several pumping stations interact with the water system. The water system is an open system with inflow and outflow; due to rainfall / precipitation, connecting water flows and ground water.

At this level the volume of water pumped, how much and when is determined. Optimisation targets can be to pump as less water as possible and make optimal use of availability of renewable energy.

3 Case studies

In this chapter a short description of each of the case studies submitted by the partners is given.

Towards Smart Pumping in the context of Dutch Water Boards water management

The Dutch Water boards (Waterschappen) are responsible for maintaining safe and secure water levels within their service region. In rainy periods, most water boards need to pump huge volumes of water in order to safeguard people, houses, roads and other economic infrastructure. Normally, the decision to pump is 'water level driven', maintaining water levels within an established range.

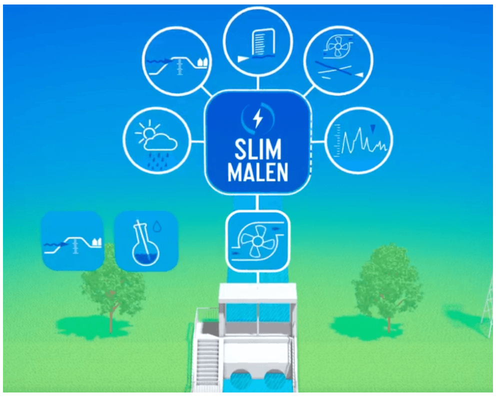

Figure 2: 'Slim malen'

Water boards can save enormous amounts of energy (and thus reduce CO2 emission) by using a smart **decision support system** that helps to efficiently steer existing pumping plants, taking into account a variety of parameters beyond water level only.

The outcomes of the analysis show that the smarter pumping regimes obtained under the Predictive Control Model lead to an average reduction of 30% of the energy use and 20% to 25% of all pumping costs. In Water board regions with a wider range of variables (for instance tides movement in the target river, locks, etc.), the improvements may increase to 80% pumping cost reduction.

The outcomes also show a 38 kton reduction of CO2 emission, which is mainly due to the replacement of fossil fuel sources by solar and wind energy, apart from the reduction obtained from less energy use. This CO2 reduction number is **80% of the current CO2 emission** (46 kton per year).

Smart Pumping 'Hardware' & 'Software'

Canal and River Trust owns and maintains 76 pumping stations throughout the canal network, which either abstract water or transfer water (including back pumping) around the network. These pumping stations currently contain 122 individual pump sets. The Trust utilise **Variable Speed Drives** (VSD's) at 13 sites and **Smart power metering** at all 76 sites. The Trust has gradually upgraded pump sites/operations to incorporate SCADA systems.

HARDWARE - More robust and reliable mechanical infrastructure (inc pumps) and instrumentation

Hardware has a current average life span of 17 years (based on 2012-17 pump replacement installations). This is shorter where poor design and models were selected, and operational conditions not suited to the selected solutions.

Pump replacement and/or early intervention is often key before unplanned or catastrophic failures cause bigger / wider / costlier problems (23 out of 38 pump replacement projects between 2012 and 2017 were due to unplanned failures so earlier replacement would have save much expense).

Costs of overhauling failed hardware has increased in recent years whilst replacement costs have fallen - so this is now often the favoured solution. More up to date equipment can be installed and given that submersible pumps are relatively simple to replace, needing limited site works and having fewer operation impacts such as closed waterways.

Flow meters and Variable Speed Drives (VSD's) need replacing as they start to age. This may require excavation of existing equipment, chamber construction and modifications to pipework. High civil engineering costs can be barriers to early / earlier replacements.

Add result

SOFTWARE - Improved Control Panels and ease of SCADA integration

Software - Control Systems

Most recent work has been to replace (increasingly unreliable) Dynamic Logic (DL) units which bring effective pump control with (currently Mitsubishi) PLC units. Upgrading these PLC units should deliver even greater efficiencies. 4 CRT pumping sites (which ones ??) still have DL outstations and are awaiting upgrades to PLC units.

SCADA also enables pump use to be monitored, examined and analysed. Pump switch on-off points can be set to water levels or to a clock timer to provide the right pound level to meet water demand. The set points can biased towards off-peak electricity timing to reduce overall pumping costs.

Add result

Energy efficiency management at Crissey pumping station (France)

Voies navigables de France operates the French inland waterways network. It is responsible for modernizing the network and the civil works. Regarding climate change adaptation needs of the hydraulic network, VNF is engaged in an ambitious modernization program including the modernisation of hydraulic equipment. The modernisation of Lock34bis at Crissey was launched in 2020.

Figure 3 : Crissey pumping station

Built in the early 1970s, Lock 34bis at Crissey is located at the eastern end of the Centre Canal, at the junction with the Saône river.

To improve water and energy consumption efficiency of the pumping station, Voies Navigables de France chose to install a new pump with a complete automation of pump control. The works took place from February to November 2020.

The two original pumps could not operate simultaneously. For an equivalent water level (Saône river level is variable), the pump on the left riverside was consuming 0.052 Kwh/m3. Based on local measurements after the new pump installation, the new pump electricity consumption is around 0.042 Kwh/m3.

The electricity consumption decreased by about 19.3% compared to previous left side pump, and by 48.1% to the right side pump. The global energy consumption reduction is estimated at 36.8%. Considering pumping a water volume of 3 000 000 m3/year on a year basis, the energy saving is around 73.000 Kwh and 4400 kg CO_2, based on the French electricity CO_2 emissions average.

4 Appendices: Factsheets case studies

Factsheet to present relevant developments / experiences

Empty template for further additions:

Experience code	*Green Win 'Country' #Nr*
Title	*Title of the project/experience/pump*
Level of intervention	*Indicate if the experience is at pump, plant or system level*
Context	*Give a short context of the experience*
Water system / setting	*More detailed description of the water system or setting.*
Aim of the experience	*Description of the aim of the experience.*
Description of the experience	*Detailed description of the experience.*
Summary of measures	*Overview of the measures.*
Estimate of CO2 reduction (and other outcomes)	*Description of the estimate of CO2 reduction, improvement of efficiency and other outcomes*
Replicability	*Possible scenarios/places where and how the experience can be used as well.*
Further information	*Extra information on the project/experience. This could include for example the research paper, a website, academic publications, similar projects.*

Experience code	Green Win NL 01
Title	**Towards Smart Pumping in the context of Dutch Water Boards water management**
Level of intervention	Canal or water system
Context	The Dutch Water boards (Waterschappen) are responsible for maintaining safe and secure water levels within their service region. In rainy periods, most water boards need to pump huge volumes of water in order to safeguard people, houses, roads and other economic infrastructure. Normally, the decision to pump is 'water level driven', maintaining water levels within an established range.
Water system / setting	All Water board regions contain areas (polders or others) located below the level of the natural drainage system. In order to maintain secure water levels in these lower areas, during rainy periods the Water boards need to pump water from collecting drains into higher located rivers or canals, or directly into the sea. Until present, Water boards usually start pumping when the water levels in the collecting drains reach a predetermined level (so called 'feedback' control). Their operational flexibility mainly consists in defining to use one or more pumps and their pump rates (e.g. water flow). Such a rather simple operation does not take into account the large number of variables that can be used in the design of a more efficient strategy to remove the surplus water: precipitation rate, storage capacity in the lower areas, discharge capacity of the collecting drains, water level in the outside river / canal, number of pumps, pump capacities, energy sources, energy prices, etc. The interplay of these variables, based on predictive models, provides enormous 'room for manoeuvre' to define innovative energy saving and CO2 reducing pumping schedules.
Aim of the experience	Water boards can save enormous amounts of energy (and thus reduce CO2 emission) by using a smart **decision support system** that helps to efficiently steer existing pumping plants, taking into account a variety of parameters beyond water level only. This kind of decision support system seeks to take the step from 'feedback control' to 'Model Predictive Control' (MPC). In the case of the Dutch Water boards, the MPC is especially aiming at: • Reduce pumping through optimising inland water storage capacity in relation to rainfall prediction and by timely pumping in relation to variable outside water levels. • Define pumping time slots that coincide with abundant electrical energy, preferably 'green' electricity. The purpose of the experience was to 1) develop the Model Predictive Control system, 2) measure the reduction of energy use and cost when applying it in actual water management practices at four pilot sites and 3) extrapolate the results for the overall Water boards' 'pumping bill'.

<table>
<tr>
<td>Description of the experience</td>
<td>A Model Predictive Control system, based on a simplified water model, was developed to define pump schedules that make optimal use of:

Rainfall forecast
Estimates of outer bounds water level (= levels to pump to).
Water storage capacity in the low lying areas
Variations in energy costs (e.g. day and night prices)
Estimates of energy surplus from sustainable energy sources (wind and solar energy)

An important input for the MPC are data from the Power Price Scenario Generator, which simulates one-day ahead electricity markets and predicts every hour energy costs and energy mixes. The use of this tool makes it possible to estimate the total reduction of CO2 emission over the year.

Another important data is the total storage capacity of inland waters. Applying a +/- 5 cm water level standard, the total Water boards' buffer capacity equals 1700 MWh.

The MPC is able to define pumping schedules for a given time slot (e.g. 72 hours) based on the prioritisation of water management goals such as water level, energy reduction, cost reduction, maximum use of green energy, etc. The pumping schedules include detailed prescriptions of number of pumps and rpm.</td>
</tr>
<tr>
<td>Summary of measures</td>
<td>
Development of Model Predictive Control system to define pumping schedules
Application of the MPC on four pilot sites
Comparison of three pumping scenarios (each also applied under different flexibility scenarios for the development of the energy market):

Water level driven
Minimization of energy costs
Optimization of CO2 emission

</td>
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<tr>
<td>Estimate of CO2 reduction (and other outcomes)</td>
<td>The outcomes of the analysis show that the smarter pumping regimes obtained under the Predictive Control Model lead to an average reduction of 30% of the energy use and 20% to 25% of all pumping costs. In Water board regions with a wider range of variables (for instance tides movement in the target river, locks, etc.), the improvements may increase to 80% pumping cost reduction.

The outcomes also show a 38 kton reduction of CO2 emission, which is mainly due to the replacement of fossil fuel sources by solar and wind energy, apart from the reduction obtained from less energy use. This CO2 reduction number is 80% of the current CO2 emission (46 kton per year).</td>
</tr>
<tr>
<td>Replicability</td>
<td>The use of a Predictive Control Model for water management and pumping plants is essentially applicable in water settings that include certain reservoir functions, since these enable for flexibility in the definition of pumping times and rates. The Predictive Model can optimise pumping schedules based on the prediction of inflow, buffer capacity and outflow.

The functioning of a Predictive Control Model for water management and pumping plants depends on the availability and reliability of some crucial components:</td>
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</table>

	• Data Integration System • Telemetric System The **Data Integration System** must collect all required data (weather, water levels, energy costs), validate the data, run the models to produce the required input for the steering model, create the steering output data and send these data to the Telemetric Systems. The **Telemetric System** is required to send to and receive data from all stations (sensors, weather stations: rainfall, wind, pumping sites, etc.). The frequency of data sending and command communication depends on the time resolution needed for every specific application. The working of the PMC is related to the **characteristics of the pumps installed**. The more flexible the pumps, the more possibilities for the MPC to steer cost and CO_2 efficient operation.
Further information	Main report (in Dutch): Slim malen – energie besparen? [Smart pumping – energy saving?], STOWA report 2019-27, STOWA, Amersfoort, 43 pp. Website: www.slimmalen.nl Academic publications: Klaudia Horvath, , Bart P.M. van Esch, Jorn Baayen, Ivo Pothof (2018), Categorization of trapezoidal open channels based on flow conditions for the choice of simple models, La Houille Blanche, Vol. 4, 2018, p. 56-64 Horvath, K. et al. (2018), Model-predictive control of a river reach with weirs, Proceedings of 13th Int. Conf. on Hydroinformatics, HIC2018, 1 - 6 July, Palermo Horvath, K., van Esch, B., Vreeken, D., Pothof, I., Baayen, J. (2019), Convex modelling of pumps in order to optimize their energy use, Water Resources Research 55, Vol. 3, p. 2432-2445. https://doi.org/10.1029/2018WR023811 Klaudia Horváth, Bart van Esch, Ivo Pothof, Tjerk Vreeken, Jan Talsma, Jorn Baayen (2019), Closed-loop model predictive control with mixed-integer optimization of a river reach with weirs, 1st IFAC Workshop on control methods for water resources systems (CMWRS2019), 19-20 September, Delft.

Experience code	Greenwin UK 01-1
Title	**Smart Pumping 'Hardware'** Variable Speed Drives & pump equipment efficiencies
Level of intervention	Pump level AND Plant level / pumping station

<table>
<tr><td>Context</td><td>Canal and River Trust owns and maintains 76 pumping stations throughout the canal network which either abstract water or transfer water (including back pumping) around the network. These pumping stations currently contain 122 individual pump sets.

25 of these pumps (33%) are used for water abstraction from river or groundwater sources to supply water to the receiving canal.
48 of these pumps (63%) recirculate or back pump water which has been displaced by boat traffic travelling through a lock or series of locks in a lock flight. They are also used to transfer water to a higher canal pound to accommodate water loss through seepage, evaporation and transpiration or for onward transfer to another length of canal.
3 of these pumps (4%) are used for flood water transfer and alleviation, to clear silt from locks, to pump sewage to sewer, and to pump surface water under specific agreements.

The Trust utilise Variable Speed Drives (VSD's) at 13 sites and Smart power metering at all 76 sites

Pumps are selected from a range of manufactures including Flygt, Sulzer and KSB. They range in motor size from 10kW to 250kW. Typical flow rates across all stations are between 0.06 m3/s to 1 m3/s

Pumping stations are typically operated in three ways depending on the age of equipment, operational or environmental constraints and funding available for upgrade.

18% 'Old set up' - Manual operation and labour intensive.
6% 'Intermediate set up' - Semi-manual operation, some use of timer clocks.
73% 'Fully automated' - SCADA controlled, pumps start when set water levels are reached.

Fully automated is becoming standard practice - allowing remote performance monitoring, diagnostics, and the ability to adjust control parameters to match resource requirements.

The Trust has gradually upgraded pump sites/operations to incorporate SCADA systems.</td></tr>
<tr><td>Aim of the experience</td><td>2 distinct topics emerging of interest that we aim to improve our knowledge about are:

HARDWARE - More robust and reliable mechanical infrastructure (inc pumps) and instrumentation

SOFTWARE - Improved Control Panels and ease of SCADA integration (see Fact Sheet 2)

Hardware has a current average life span of 17 years (based on 2012-17 pump replacement installations) This is shorter where poor design and models were selected, and operational conditions not suited to the selected solutions.

Pump replacement and/or early intervention is often key before unplanned or catastrophic failures cause bigger / wider / costlier problems (23 out of 38 pump</td></tr>
</table>

<table>
<tr><td></td><td>replacement projects between 2012 and 2017 were due to unplanned failures so earlier replacement would have save much expense)

Costs of overhauling failed hardware has increased in recent years whilst replacement costs have fallen - so this is now often the favoured solution. More up to date equipment can be installed and given that submersible pumps are relatively simple to replace, needing limited site works and having fewer operation impacts such as closed waterways.

Flow meters and Variable Speed Drives (VSD's) need replacing as they start to age. This may require excavation of existing equipment, chamber construction and modifications to pipework. High civil engineering costs can be barriers to early / earlier replacements.</td></tr>
<tr><td>Description of the experience</td><td>Trial solutions and through expert exchanges find best practices. Including:
How to enhance older pumping equipment to provide maximum efficiency.
How to integrate new pieces of equipment into existing infrastructure, a common approach and validate new tools which will have significant benefits.
Jointly develop a tool kit to allow multi pump manufacturer comparisons (currently manufacturers tools are for their own ranges and specialist pump design software is geared towards new build rather than re build / development)
Assess typical pumping failure types and what problems these cause:
Blockage due to vegetation debris, mechanical failure, electrical failure. (Overload)
Low / erratic flow and reduced / poor flow presentation due to blocked intake screens or siltation build up. (Flow)
Overheating due to lack of water around pump body causing blocked intake screens (Thermal)
Mechanical failure of bearing seals allowing to water to leak from the pump volute to the motor pump seal (Leakage)
(The Trust has had problems with both the above and whilst both are covered by preventative and reactive maintenance contracts - these are costly and any efficiencies we can introduce through Green WIN will reduce overall running costs)

Test improvements (in Liege test tank and in situ) that deliver pump system efficiencies:
Testing variable speed drives (VSD) that enable variation in the speed of the pump motor and allows adjustment in power consumption to fine tune a pump to its best efficiency point (BEP).
Assessing pumping stations to check suitability for VSD installation (not all pumps or systems are suitable for VSD equipment).</td></tr>
<tr><td>Summary of measures</td><td>Efficiencies and good/best practice will be found through
expert assessments provided by partner exchanges and technical expertise from Arcadis
pump efficiencies found through testing in the Liege Test facility and
in situ trials in the UK at Tinsley, Seend, Caen Hill and Calcutt
Specific targets are (later we can change to 'were') to develop</td></tr>
</table>

	• Simple pump system design and evaluation tool. Geared towards waterways rather than sewage. Understanding how compromised design is affecting pump performance and life span • We are looking for solutions to not only pump selection but other enhancements to design which can mitigate trash issues. (Trash and debris handling is a significant challenge and affects nearly all our stations) • VSDs cost benefit analysis and better understanding on compatibility with different pump manufacturers. Look at the importance of BEP matching. Harmonic impact and effect on 'weak' supplies. Evidence of bearing failure following the use of VSD. • Supply load balancing to grid with variation in speed control and stop start. True cost benefit and impact on service life needs investigating.
Estimate of CO2 reduction (and other outcomes)	*We will need to agree which figure we select here? We can include all sites as we have data OR split by the sites we think the new / improved solutions can be applied to?*
Replicability	
Further information	

Experience code	Greenwin UK 01-2
Title	**Smart Pumping 'Software'** (Control Panels & SCADA instrumentation)
Level of intervention	Plant level / pumping station AND System level (canal/water system)
Context	Canal and River Trust owns and maintains 76 pumping stations throughout the canal network which either abstract water or transfer water (including back pumping) around the network. These pumping stations currently contain 122 individual pump sets. • 25 of these pumps (33%) are used for water abstraction from river or groundwater sources to supply water to the receiving canal. • 48 of these pumps (63%) recirculate or back pump water which has been displaced by boat traffic travelling through a lock or series of locks in a lock flight. They are also used to transfer water to a higher canal pound to accommodate water loss through seepage, evaporation and transpiration or for onward transfer to another length of canal. • 3 of these pumps (4%) are used for flood water transfer and alleviation, to clear silt from locks, to pump sewage to sewer, and to pump surface water under specific agreements. The Trust utilise **Variable Speed Drives** (VSD's) at 13 sites and **Smart power metering** at all 76 sites

Experience code	Greenwin UK 01-2
	Pumps are selected from a range of manufactures including Flygt, Sulzer and KSB. They range in motor size from 10kW to 250kW. Typical flow rates across all stations are between 0.06 m3/s to 1 m3/s Pumping stations are typically operated in three ways depending on the age of equipment, operational or environmental constraints and funding available for upgrade. • 18% 'Old set up' - Manual operation and labour intensive. • 6% 'Intermediate set up' - Semi-manual operation, some use of timer clocks. • 73% 'Fully automated' - SCADA controlled, pumps start when set water levels are reached. Fully automated is becoming standard practice - allowing remote performance monitoring, diagnostics, and the ability to adjust control parameters to match resource requirements. The Trust has gradually upgraded pump sites/operations to incorporate SCADA systems.
Aim of the experience	2 distinct topics emerging of interest that we aim to improve our knowledge about are: HARDWARE - More robust and reliable mechanical infrastructure (inc pumps) and instrumentation (see Fact Sheet 1) **SOFTWARE - Improved Control Panels and ease of SCADA integration** Software - Control Systems Most recent work has been to replace (increasingly unreliable) Dynamic Logic (DL) units which bring effective pump control with (currently Mitsubishi) PLC units. Upgrading these PLC units should deliver even greater efficiencies. 4 CRT pumping sites (which ones ??) still have DL outstations and are awaiting upgrades to PLC units. SCADA also enables pump use to be monitored, examined and analysed. Pump switch on-off points can be set to water levels or to a clock timer to provide the right pound level to meet water demand. The set points can biased towards off-peak electricity timing to reduce overall pumping costs.
Description of the experience	**Trial solutions and through expert exchanges find best practices. Including**: • How to enhance older pumping equipment to provide maximum efficiency e.g. Gloucester • Integrating new pieces of equipment into existing infrastructure is our common approach and tools to assist with this will have a significant benefit • A tool kit to allow multi pump manufacturer comparisons. Currently manufacturers tool are for their own ranges and specialist pump design software is geared towards new build rather than re build / development. • Need more info to support SCADA PROPOSAL

Experience code	Greenwin UK 01-2
	Assess typical failure types and what they cause (we want to address) are: • Control Panel SCADA Communication –modem or router failure cutting communication to SCADA servers. Can prevent operation when remote water level instrumentation is utilised • Control Panel Equipment –failure of a component inhibiting or preventing operation of pumping equipment such as a call to run relay • (Hardware or software??) Field Equipment Instrumentation –failure of a water level transducer affecting the operation of the site either preventing pumping equipment being called when required or causing excessive pumping **Trial Pumping SCADA Control & Set Points** • Installation of SCADA telemetry and level instrumentation on a pumping station enhances CRT's control options and is considered as part of the (site upgrade) prioritisation process. (Each site has a Water Management Operational Procedure which documents the level reference or datum control point for the SCADA instrumentation and defines the optimum control parameters for the site's operation)
Summary of measures	**Efficiencies and good/best practice will be found through** (1) expert assessments provided by partner exchanges and technical expertise from Arcadis (2) pump efficiencies found through testing in the Liege Test facility and (3) in situ trials in the UK at Tinsley, Seend, Caen Hill and Calcutt **Specific targets are (later we can change to 'were') to develop** (4) Supply load balancing to grid with variation in speed control and stop start. True cost benefit and impact on service life needs investigating. (5) *(need to add others)*
Estimate of CO2 reduction (and other outcomes)	*We will need to agree which figure we select here? We can include all sites as we have data OR split by the sites we think the new / improved solutions can be applied to?*
Replicability	
Further information	Developments Highlighting Inefficient Sites CRT's Annual Pumping Report compares usage and power consumed at all Pumping Stations. The power consumed per volume of water raised (kW/Ml/m) indicates the relative efficiency for each pumping system. This figure provides a tool to focus on poorly performing sites. This is part of System level (canal/water system) Uses Liege hydrological modelling work + RWS 'bigger picture' expertise Electricity network supply load balancing - Trust status 8 sites Overarching SCADA A series of pumping stations operating independently occasionally create imbalances in individual canal pounds leading to a deficiency in pumping or excessive pumping leading to waste. A project of Overarching SCADA is underway which aims to design

Experience code	Greenwin UK 01-2
	and implement a system which controls the chain of pumps as a whole. Pumping regimes will be developed to achieve either net transfer of water or lock recirculation as required in all conditions i.e. summer or winter, drought, normal or flood conditions, night time or daytime. Each pumping regime will be designed to be efficient so as to minimise the cost of pumping and eliminate any water that is pumped to waste. A further objective is to contribute to the reduction of CO^2 emissions as part of the Trust's carbon management plan. Power Grid Demand Balancing Working with energy providers, the Trust has linked suitable pumps to an energy management system which can under/over speed pumps or alternatively switches pumps on or off allowing the release of energy or absorb excessive energy back to the National Grid to even out its temporary peaks and troughs in demand. This reduces the demand in standby power stations and allows the greater use of green powers sources such as wind and solar. These short-term interventions generate revenue for the Trust and in turn helps to reduce carbon emissions.

GREENWIN FACT SHEET- Crissey

Experience code	Green Win FR 01
Title	Energy efficiency management at Crissey pumping station (France)
Level of intervention	Pump system
Context	Voies navigables de France operates the French inland waterways network. It is responsible for modernizing the network and the civil works. Regarding climate change adaptation needs of the hydraulic network, VNF is engaged in an ambitious modernization program including the modernisation of hydraulic equipment. The modernisation of Lock34bis at Crissey was launched in 2020. Built in the early 1970s, Lock 34bis at Crissey is located at the eastern end of the Centre Canal, at the junction with the Saône river.
Water system / setting	At each lock use, a large volume of water flows out of the upper reach (2200 m3). This volume quickly brings down the level of the reach. This is why a pumping station was installed to raise the water from the Saône immediately in the reach. The pumping station consisted of two non-submerged pumps, which after 50 years of duty have become obsolete and ineffective.
Aim of the experience	To improve water and energy consumption efficiency of the pumping station, Voies Navigables de France chose to install a new pump with a complete automation of pump control. The works took place from February to November 2020.

Description of the experience	The pump works consisted of: • The automation of the pump control in order to control the water level in the upstream reach • The installation of a new pump. Particular attention was pais to the correct sizing and technical performances of the pumps for optimal hydraulic and energy efficiency. Beyond that, the electrical system was modernized and the evacuation of floods secured.
Summary of measures	The installed pump is a Xylem Flygt CT 3400/735 3-830 (nominal power 125 kW). Downstream, the height of the Saône varies. The manometric head (HMT) is between 6.26 and 12.53 m, for a flow rate between 630 l/s and 860 l/s. The pumping system can operate in manual or automatic mode. Automatic mode is preferred. The automaton calculates at a regular time step, the time necessary to raise the reach to expected level. Based on this calculation, the pump starts at the calculated time so that the reach is level early in the morning. This is done for three main reasons: • In order to limit pumping volumes, the pumping delay makes it possible to take into account the quantities of water that could arrive from upstream (water from the upstream reaches, rainfall, part of the rainwater from the town of Chalon that arrives in this reach); • Pumping during the cooler hours and therefore when evaporation is lower; • Pumping during off-peak hours and thus limit the demand for power on the French energy network. In addition, in certain French contracts, energy consumption per hour is offered at a reduced rate. The electrical installation of the pump is also provided with a reactive energy compensator. Capacitors absorb the additional power demand when starting the pump. The pump flow rates are controlled with a Krohne brand flowmeter. It consists of an optiflux 2000 electromagnetic measurement sensor and an IFC 100 measurement converter. Pumping system data are collected into the controller and sent to VNF water supervision system.
Estimate of CO2 reduction (and other outcomes)	The two original pumps could not operate simultaneously. For an equivalent water level (Saône river level is variable), the pump on the left riverside was consuming 0.052 Kwh/m3. Based on local measurements after the new pump installation, the new pump electricity consumption is around 0.042 Kwh/m3. The electricity consumption decreased by about 19.3% compared to previous left side pump, and by 48.1% to the right side pump. The global energy consumption reduction is estimated at 36.8%. Considering pumping a water volume of 3 000 000 m3/year on a year basis, the energy saving is around 73.000 Kwh and 4400 kg CO2, based on the French electricity CO2 emissions average.
Replicability	VNF operates 85 pumping stations on the French hydraulic network. The experience is aiming at being extended to other pumping station within the VNF hydraulic modernisation program. VNF aims at saving 20% on energy consumption of pumping operations on VNF network. https://www.vnf.fr/vnf/accueil/contact/

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