DECISION LAB

IMPROVING THE UNDERSTANDING OF HOUSEHOLD WATER CONSUMPTION

REQUIREMENT
UKWIR wanted to understand household water consumption better, leading to insights to help address one of its Big Questions: "How do we halve freshwater abstractions in a sustainable way by 2050?"

CHALLENGE
Dealing with large quantities of data of highly varied types, granularity and quality before drawing out meaningful and useful insights.

SOLUTION
Using data driven analytics and machine learning techniques we developed the framework that helps us understand household consumption of water by building customer profiles of demand.

CLIENT

UKWIR
UK Water Industry Research

Understand your consumers to create an impact on them

"How do we halve freshwater abstractions in a sustainable way by 2050?" This is one very ambitious and tough question that UK Water Industry Research (UKWIR) set out to answer in its Big Question programme.

To begin to answer this we first need an improved understanding of water consumption by people and businesses. This can then help with the management and planning of our precious water resources as well as developing a means of targeting water efficiency measures.

Data. Data. And more (messy) data

How do you build a picture about people's water use? What if it is the whole population you need to consider? How do you differentiate between different people? The answer is to analyse data to extract insights to understand different behaviour types. The more data, the clearer and more relevant it is, the more accurate picture you'll be able to build.

This was the case in this highly challenging project. We were provided data from several water companies, data that spanned various levels of granularity, from annual billings to 15-minute smart meter data. There was a big variation in data quality, with many duplications, missing values and errors. But to obtain solid insights you need data that is clean and well-structured and that makes sense – this provides the solid foundation for the analysis.

The trigger point learnings from the customer segmentation

This was a collaborative project with three companies working together. Mease consultants worked with water companies to identify data sources to use and advise us on the specific meaning of the information. Decision Lab carried out the data analysis and created algorithms to clean, process and extract insights into consumer behaviour. To this end, consumer segments were identified, as well as specific features of each group were explored and their associations with patterns of demand were determined. Project leads, HR Wallingford, then employed the research outputs from Decision Lab's data analysis to develop an integrated representation of current and future water consumption and what drives it.

## Applying Machine Learning to see consumer behavioural patterns

After carrying out a thorough clean-up process on the raw data, we were able to start building a clear picture out of the vast and disperse inputs of information. We relied on a data driven approach that used data science techniques to extract insights from the large amounts of information from the water companies. This identified key features in the data for us to focus on. We used machine learning techniques to cluster the consumers into groups of distinct water usage profiles. The clusters that emerged as well as their characteristics were explored, and we identified a visible pattern of households moving between clusters, for example between different seasons, months or days of the week. This finding suggested that water use behaviour patterns are more dynamic than previously anticipated. Furthermore, we found that the highest water using groups make up 10% of households but consume 25% of total water – an insight that is valuable for targeting those consumers with water efficiency campaigns. Overall, we developed a powerful approach for understanding consumer demand through identifying groups of distinct water consumption profiles and exploring the drivers of such behaviour.

A lively spring of insights for future gains

As Paul Merchant, UKWIR Programme Lead and Supply Demand Manager at South West Water, says: "This project has brought together a huge amount of data on household water use and gives water companies a tantalising glimpse of a completely new way of understanding and reducing demand for water. This project supports the idea that the effect of customer behaviour has a bigger impact on water consumption than socioeconomics or weather. This provides potential new avenues for how companies target their water efficiency activities and assess the likely impacts."

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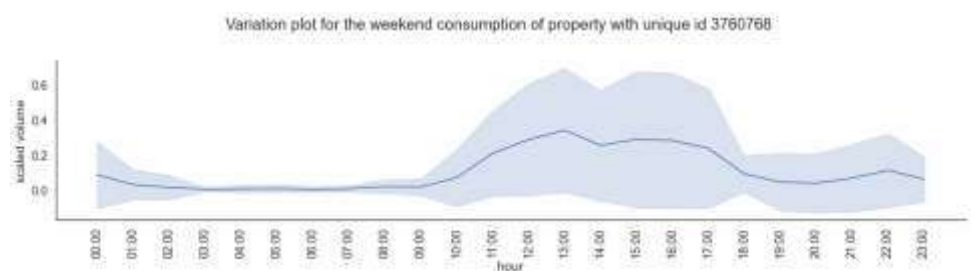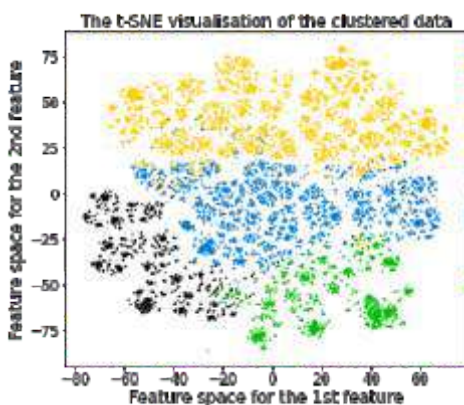
Model Screenshots
Clustering of micro-components

Difference in daily consumption of a house (weekday/weekend):

DECISION LAB

BEST VALUE FRAMEWORK

REQUIREMENT
UK Water Industry Research (UKWIR) needed a single unified framework for Best Value Planning of the Water Investment Plan that water companies submit to regulators.

CHALLENGE
Developing a pragmatic yet rigorous and defensible framework to help water companies think through complex multidimensional water resource management plans, characterised by an uncertain future and difficult trade-offs.

SOLUTION
A comprehensive framework that uses Decision Lab's approach to MCDA and considers technical, economic, environmental and legal perspectives. It provides clear practical guidance for the development of Best Value Plans.

CLIENT

UKWIR
UK Water Industry Research

Helping the water companies to get out of deep water

There is a new requirement for a Best Value Plan (BVP) to be included in water companies' regulatory Water Resource Management Plans (WRMPs) submissions. However, there are no consistent guidelines for this task. This has thwarted efforts from water companies to produce their WRMPs and in some instances caused problems with the acceptance of plans by stakeholders.

We joined a team led by HR Wallingford, leading experts in the water sector, to create a unified framework for developing BVPs. The diverse team of specialists included economists, planning and environmental professionals, and experts in law. Decision Lab's technical specialism lies in objective methods to support complex decision making as well as water investment modelling.

Complex interactions

It is a significant challenge to develop an approach that will be used as one unified decision-making instrument. Water resourcing is particularly challenging, as it is characterised by several available courses of action in a changing and uncertain environment, complex interactions between different stakeholders and sectors with often conflicting perspectives on numerous both quantifiable and intangible objectives.

The framework must be flexible enough to be practical for different types of contexts faced by water companies, and careful explanations are needed for its widespread acceptance and adoption.

One valuable tool to help drive many best value plans

The team's diverse skillset allowed us to consider technical, economic, environmental and legal perspectives, providing clear practical guidance for the various stakeholder groups. Decision Lab's key contribution was the development of the methodology core: a five-step framework centred on Multi-Criteria Decision Analysis (MCDA). Our MCDA approach is grounded in best practice decision science theory, including cognitive psychology, facilitation and negotiation.

This value-based approach ensures all relevant criteria are considered, enabling the quantification of stakeholders' value judgements combined with performance measurements. It fosters a shared understanding of a decision problem and highlights areas of important disagreement which in turn enriches discussions. Importantly, it forms a transparent link between judgements and decisions on courses of actions selected.

To ensure acceptance and adoption of the framework, we worked closely with regional groups, water companies and regulators to refine the steps.

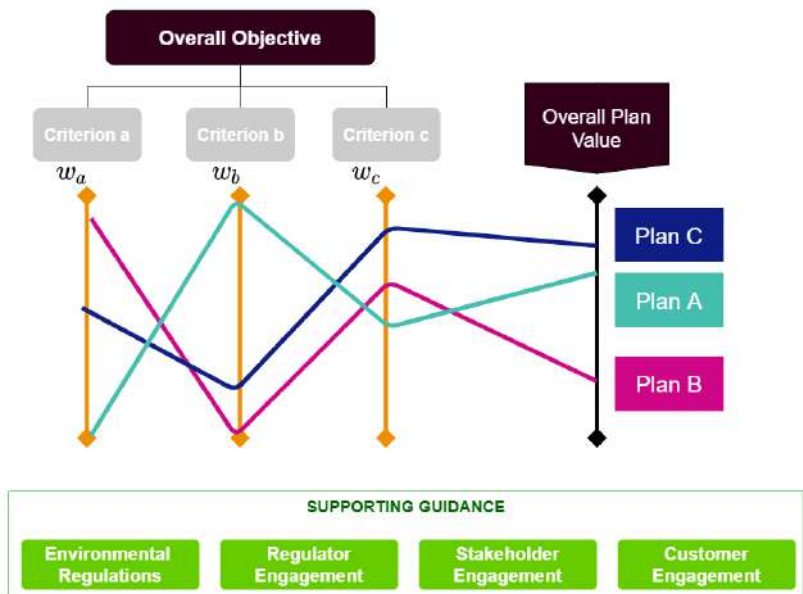## Beyond water: best value for all utilities

The developed approach has been published and is available from the UKWIR website (ukwir.org/deriving-a-best-value-water-resources-management-plan). It is being used by water companies as guidance to produce their Best Value Plans and is included in the Environment Agency's recommendations for programme appraisal and comparison.

The developed framework sets a precedent for the other markets and sectors that can benefit from a clear guide that helps to develop the Best Value Plan.

GENERIC APPROACH FOR DEVELOPING A BEST VALUE WATER RESOURCES PLAN

Step 1: Problem Structuring

Step 2: Define Value criteria and constraints

Step 3: Determine performance of alternatives against criteria

Step 4: Determine scores and weights

Step 5: Evaluate and compare alternative plans

KEY: Engagement with stakeholders, regulators, customers and environmental assessment

Overall Objective

Criterion a w_a Criterion b w_b Criterion c w_c

Overall Plan Value

Plan C
Plan A
Plan B

SUPPORTING GUIDANCE

Environmental Regulations | Regulator Engagement | Stakeholder Engagement | Customer Engagement

Find out how we might be able help you at **www.decisionlab.co.uk**

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TRANSFORMING MAINTENANCE AND INVESTMENT IN THE NATION'S CANALS

REQUIREMENT
The Canal & River Trust needed a decision-making framework that would help them to understand the condition of their diverse assets, schedule their maintenance and provide a well-planned investment strategy.

CHALLENGE
Dealing with a huge variety of assets and turning qualitative assessments from subject matter experts into quantified predictions were the main challenges our approach had to address.

SOLUTION
Our cloud-based mathematical model, designed to work in an efficient feedback loop with expert engineers, allowed the Trust to plan both operationally and strategically in ways that were previously impossible and support its transformation into a Wellbeing Trust.

CLIENT

Canal & River Trust
Making life better by water

The custodian of the waterways
The Canal & River Trust looks after one the UK largest national and historic assets – the canals and waterways of England and Wales. One of its objectives is to improve the wellbeing of the nation and ensure that more than 2,000 miles of historic inland waterways are accessible and available for use by the population.

To achieve this goal, they need to decide how best to spend their annual £100m asset maintenance budget. This decision-making framework for investment planning and scheduling needed to be a risk-based approach, consistent across asset classes, meaningful to engineers, and justifiable to stakeholders. With an old and deteriorating asset base it's crucial that the Trust spends its money carefully, focusing on repairing and replacing what matters most.

The challenge
The approach needed to work across their huge variety of assets (canals, buildings, mechanical and electrical equipment, waterways and reservoirs, culverts, weirs and many more). The ages of these assets range from modern data communication equipment to items more than 200 years old. Assets fail in many different ways, and these have different effects and require different pre-emptive interventions. The greatest challenge was the data; they had very little quantitative data on asset condition and historical failures and relied heavily on qualitative assessments from subject matter experts (SMEs).

Starting

Desirable

Budget Constrained

Without

Unconstrained

Risk Constrained
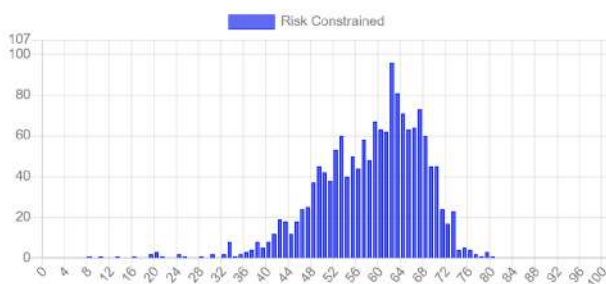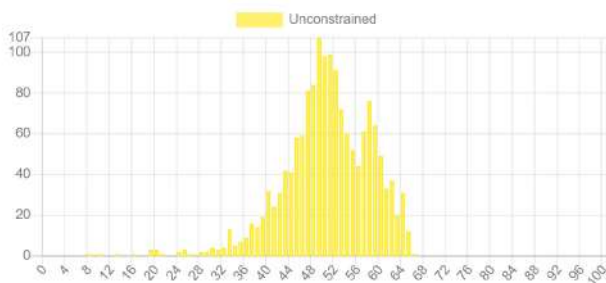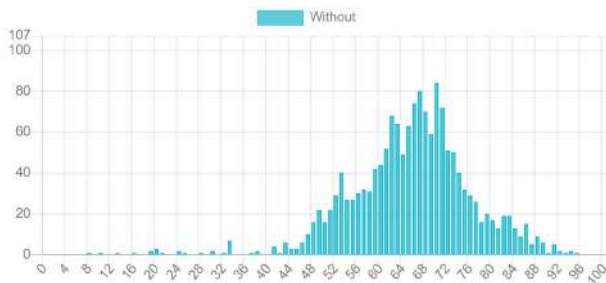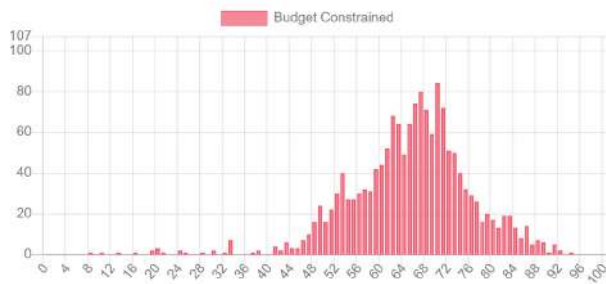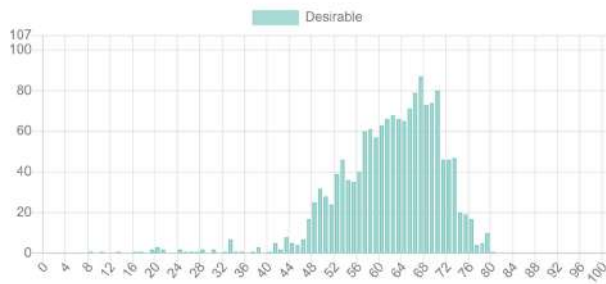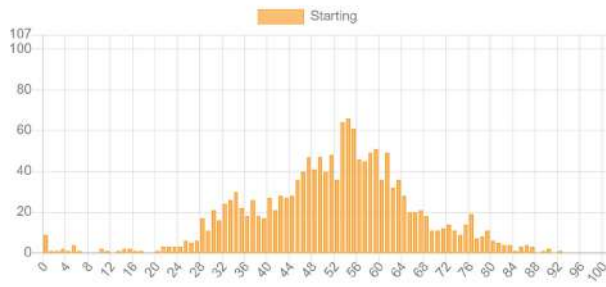
A collaboration between engineers and mathematicians

Decision Lab was well placed to meet the challenge as we had experience working on similar problems in other sectors. What the Trust lacked in data, it had an abundance of engineering expertise, and we used this to drive the solution: an engineering-led approach that translated expert judgement into a mathematical framework. It involved a close working relationship between the Trust's engineers and our analysts, as we came to understand their assets and they learned how modelling could be applied. It was rewarding and productive for all, and it was crucial to the project's success.
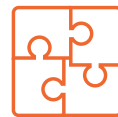
Developing a common methodology for the end user

At its heart we developed a mathematic model that used a new model approach. This approach was based on established theory but adapted and extended for our application. We also focused on providing a tool that used the assessment information the Trust could collect. We built it as a modern web application, hosted on the cloud, and we designed it to allow the engineers to build up their asset description and model themselves, reworking it until it matches what they know about their assets and the data they do have, before they produce investment strategy plans for their assets.

The tool we created could be applied to the extraordinary variety of asset types, transforming the way the Trust manages its network of assets.

An exciting journey ahead for this new transformation

The Trust now has knowledge that it never had before. It is able to plan both operationally and strategically in ways that were previously impossible. The results are feeding into business planning at all levels of the organisation. It provides them with confidence that they are investing wisely in their assets and it will help them negotiate their next funding with the Government.

We feel proud to be supporting the Canal & River Trust in its transformation to a Wellbeing trust.

Find out how we might be able help you at
www.decisionlab.co.uk