Creating a world fit for the future

Identifying policy options for incentivising rainwater harvesting and grey water recycling systems in the UK

Report for Waterwise

WEStrategy002

ED 13617100 | Issue number 1 | Date 04/09/2020

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Customer:

Waterwise (supported financially by the Water Industry Water Efficiency Collaborative Fund)

Customer reference:

WEStrategy002

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1 Introduction

In the face of significant pressure on water resources within the UK there is a distinct need to manage and use existing supplies as efficiently as possible. Our changing climate is causing more extreme weather conditions with extended periods of drought and more frequent, intense rainfall becoming the norm. This coupled with a rising population means that water shortages and flooding will become an increasing problem in a number of regions across the country. With population in the UK set to increase significantly by 8.7 million by 2050, the new homes and services required will place a significant additional demand on water and sewerage services and will severely exacerbate the risk of surface water flooding in many urban areas.

The Water UK 'Water resources long-term planning framework (2015-2065)'(Water UK, 2016) stated that a 'twin-track' approach of increasing supply and reducing demand is needed in order to secure the resilience of water supplies over the next 50 years. The National Infrastructure Commission's report 'Preparing for a drier future: England's water infrastructure needs' (National Infrastructure Commission, 2016) supported the need for this approach suggesting that two thirds of the additional capacity required to maintain the current level of resilience should come from demand management measures. The report stated that increasing efficiency savings and near universal smart metering would reduce the average per capita consumption (PCC) from the current 141 litres/person/day to 118 litres by 2050. Further to this the Environment Agency's National Framework for Water Resources suggests a planning assumption of 110 l/p/d is adopted (Environment Agency, 2020).

To achieve this reduction in PCC developers will need to consider going beyond the traditional water efficiency measures such as low flush toilets and low flow showers. Rainwater harvesting (RWH) and grey water recycling (GWR) technologies offer a potential solution and are increasingly being considered at the building-level as a means for addressing water scarcity and stormwater attenuation. To date, both rainwater harvesting and grey water recycling systems have been implemented with mixed experience in the UK. Technical concerns regarding water quality, potential cross connections and issues around the social acceptability of using recycled water have all been barriers to uptake. Further to this a 2011 Environment Agency (EA) report on the carbon implications of these systems suggested that due to pumping and treatment they are often more carbon intensive than the public water supply (Environment Agency, 2011). However, an independent review of the costs and benefits of rainwater harvesting and grey water recycling options in the UK concluded that carbon emissions vary depending on the type of system installed and that recent innovations have led to lower energy demands relative to mains water (Waterwise, 2020). Additionally, the payback periods and return on investments can be obtrusive for some systems but may benefit from economies of scale if they are introduced at a development scale or centralised within an existing community.

Following a review of the policy options and incentives used to encourage the uptake of RWH and GWR technologies in the UK and abroad, this report provides a list of potential policy options that could be adopted in this country. Each of the different policy options has been modelled to assess the cost and benefits and impacts to PCC, non-domestic water usage and the zero carbon agenda.

2 Identify policy options for incentivising RWH and GWR

2.1 Introduction

As set out in Water UK's 'Water resources long-term planning framework (2015-2065)' a 'twin-track' approach of increasing supply and reducing demand is required in order to secure the resilience of water supplies over the next 50 years (Water UK, 2016).

Both RWH and GWR systems offer potential decentralised solutions in reducing water demand and increasing available water supply. Furthermore RWH systems can also be useful in the reduction of flood risk in urban areas. However, uptake in the United Kingdom (UK) has to date been limited in comparison to some other European countries where legal and economic conditions have been created to support or enforce the use of RWH as part of climate, environmental and social policies (Struk-Sokołowska et al., 2020). Further to this the high price of drinking water has increased the popularity of rainwater systems in countries such as Austria, Sweden, Switzerland, Belgium and Denmark (Godskesen et al., 2013).

Drawing from stakeholder insight and published grey and academic literature this section provides an overview of the current regulatory and policy framework and the market barriers which have affected uptake of RWH and GWR technologies in the UK. In considering the policy options and incentives that are provided in other countries to drive the uptake of these systems, a list of possible policy options that could encourage uptake in certain building types in the UK has been identified, including for new buildings, retrofits and non-domestic buildings.

2.2 Current drivers for uptake

A summary of the main regulatory and policy drivers which cover water consumption and sustainable urban drainage in new buildings and provide the legislative framework for the installation of rainwater and grey water technologies in the UK are outlined below.

2.2.1 Code for Sustainable Homes

An initial key driver for the installation of rainwater harvesting and grey water recycling systems was the Code for Sustainable Homes (The Code) which provided a voluntary national standard for the sustainable design and construction of all new homes. Introduced in England in April 2007, the Code provided performance targets which were more demanding than the minimum standards specified in Buildings Regulations and other legislation. Mandatory minimum standards were also set for specific areas, including indoor water use (Table 2-1).

Table 2-1. Assessment criteria for indoor water use in Code for Sustainable Homes (DCLG 2010)

Water consumption (litres/person/day)	Credits	Mandatory levels
≤120 l/p/day	1	Levels 1 and 2
≤110 l/p/day	2	-
≤105 l/p/day	3	Levels 3 and 4
≤90 l/p/day	4	-
≤80 l/p/day	5	Level 5

While the lower levels of the Code could typically be met through the installation of water efficient fixtures and fittings, developers were needed to consider rainwater harvesting and grey water recycling to achieve the higher levels (<100 l/p/day). Between 2008 and 2010 the Code became mandatory as

house sellers were required to provide buyers with Home Information Packs which detailed the sustainability rating of the building. After this point and up until March 2015, the Code remained mandatory in England, Wales and Northern Ireland if it was a requirement of a Local Authority's Local Plan[1] or where affordable housing was funded by the Homes and Communities Agency[2]. However, following the technical housing standards review the policy was withdrawn and a new set of streamlined national technical standards, driven by Buildings Regulations was introduced.

2.2.2 Buildings Regulations 2010 (amended 2015)

The Building Regulations is a statutory instrument that seeks to ensure that the policies set out in the relevant legislation are carried out. They cover the construction and extension of buildings and are supported by Approved Documents which set out detailed practical guidance on compliance with the regulations.

- In England and Wales, Approved Document G (Part G: Sanitation, hot water safety and water efficiency) sets out the minimum standards for water consumption in new dwellings. In England, this is 125 l/p/day with an optional target of 110 l/p/day where specified (HM Government 2016). In Wales, an amendment to Part G, which came into force in November 2018, stipulates a minimum standard of 110 l/p/day in new dwellings. Approved Document H (Part H: Drainage and waste disposal) also covers rainwater and grey water tanks and stormwater drainage (HM Government 2015).
- In Scotland, Section 3 (Environment) of the Buildings Standards Technical handbook 2017 covers water efficiency and surface water drainage however, specific water consumption targets are not currently specified in the technical guidance[3].
- In Northern Ireland, water and drainage are covered in Technical Booklets P and N but as in Scotland, specific water consumption targets are not currently specified in the technical guidance[4].

2.2.3 SuDs and the National Planning Policy Framework 2019

Sustainable drainage systems (SuDs) are a natural approach to managing drainage in and around properties and other developments. As well as helping to reduce the causes and impacts of flooding by holding back the water that runs off from a site, SuDs can also provide additional benefits such as removing pollutants from urban run-off and combining water management with green space that offers scope for recreation and wildlife.

Through the implementation of the Flood and Water Management Act 2010[5], SuDs were intended to be mandatory for all major development throughout England and Wales. Schedule 3 of the Act proposed to establish a SuDs approval body (SAB) at the county council and unitary authority level. However, this was only enacted in Wales, where SuDs are now a requirement for all new developments of more than one dwelling or where the construction area is 100 square meters or more (Welsh Government 2019).

In England, Schedule 3 of the Act was not enacted and the National Planning Policy Framework (NPPF) 2019 was amended to require the delivery of SuDs for major developments (10 dwellings, or equivalent non-residential developments) unless there is clear evidence that this would be inappropriate (Ministry of Housing, Communities and Local Government, 2019). The NPPF sets out the policy approach for preventing inappropriate development in areas at risk of flooding. When determining planning applications the NPPF expects local planning authorities in England to ensure (through its local plans) that sustainable drainage is prioritised in areas at risk of flooding. The planning guidance supports the

[1] https://www.gov.uk/guidance/local-plans
[2] https://data.gov.uk/dataset/4fef1dc8-4056-4f5e-84a3-22f2d0e928cf/affordable-housing-starts-and-completions-funded-by-the-homes-and-communities-agency-and-the-greater-london-authority
[3] See https://www.gov.scot/publications/building-standards-2017-domestic/0-general/01-application/
[4] See http://www.buildingcontrol-ni.com/regulations/technical-booklets
[5] http://www.legislation.gov.uk/ukpga/2010/29/contents

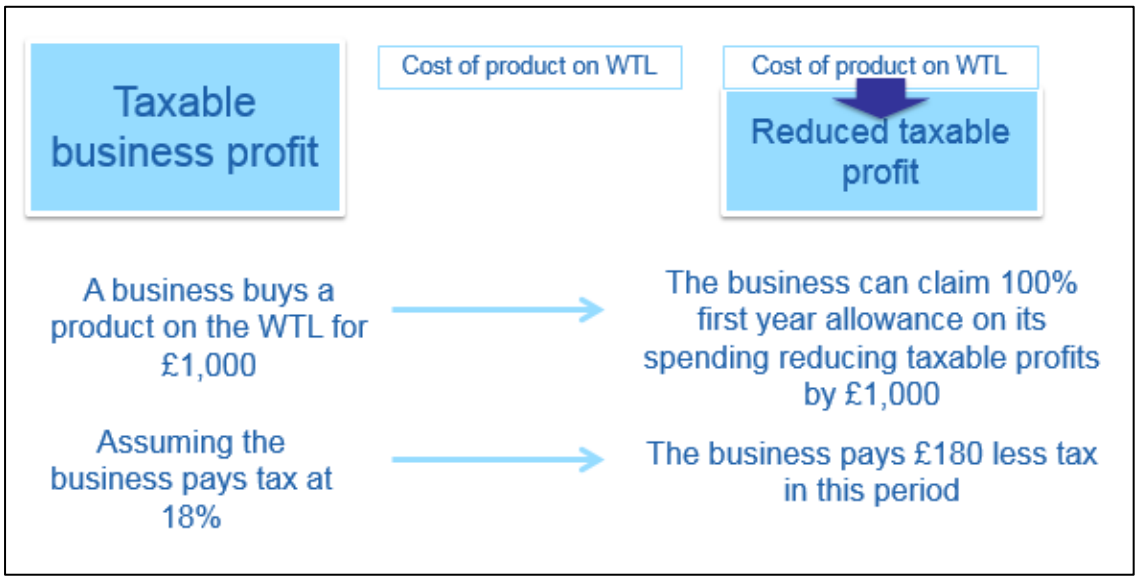
NPPF, setting out the types of sustainable drainage systems that should be considered according to a hierarchy of drainage options. In April 2015, Defra published Non-Statutory Technical Standards (NSTS) for Sustainable Drainage Systems, covering their design, maintenance and operation (Defra, 2015).

In Scotland SuDs are a legal requirement for all developments except single dwellings that drain to the water environment unless they discharge to coastal waters[6] and in Northern Ireland SUDs are a requirement under Section 4 of the Water and Sewerage Services Act (2016)[7].

2.2.4 Enhanced Capital Allowances and Water Technology List

Under the Capital Allowances Act 2001, the Enhanced Capital Allowance (ECA) scheme was designed to encourage businesses to invest in more sustainable technologies. The scheme allowed businesses to offset 100% of the cost of a capital asset against taxable income in the year of purchase. In this way, the ECA provided a cash flow boost, shortening the payback period on the investment (Figure 2-1).

Figure 2-1 Summary of financial incentive provided by ECA scheme



Launched in 2003, the Water Technology List (WTL) provided the mechanism through which the ECA scheme was delivered for water efficient products and technologies. The WTL set out the eligibility criteria for each technology category and sub-category and provided a list of eligible products for purchasers. Eligibility criteria for each technology category was developed based on industry standards, performance and testing requirements. The criteria was updated, through the annual review process, as appropriate to ensure that it continued to reflect the technology area, current performance standards and the market.

Initially launched with five product categories, the WTL grew significantly covering fourteen product-based technology categories (comprising 35 sub-categories) with 4,660 eligible products and a 'systems' based category (technologies that enable reuse and recycling of treated wastewater). Rainwater harvesting equipment and grey water recycling equipment were introduced into the scheme in 2004 and 2014 respectively. However, uptake in these categories significantly contrasted with over 1,800 individual product applications received for rainwater harvesting equipment and only one for grey water equipment. In 2020, the ECA scheme was closed by HM Treasury and support for investments withdrawn.

[6] https://www.susdrain.org/delivering-suds/using-suds/legislation-and-regulation/scotland.html
[7] https://www.infrastructure-ni.gov.uk/sites/default/files/publications/infrastructure/water-and-sewerage-services-act-ni-2016.PDF

2.2.5 Water industry infrastructure connection charges

In addition to the regulatory drivers outlined above a number of water companies in England, particularly those operating in water stressed regions, have offered discounts on infrastructure connection charges for new developments that go beyond the 125 l/p/day water consumption target set out in the Buildings Regulations (Table 2-2).

Table 2-2 Examples of water company incentives offered on infrastructure connection charges

Water company	Charges / property	Incentive / discount	Water efficiency target	Outcome / comments
Anglian Water	£740[8] per plot	100%	100l/p/day	The water efficiency incentive aimed to help reduce water use in new homes across the region. Where premises were built to a water efficiency standard of 100 litres per person per day, the fixed element of the zonal charge could be refunded. The water efficiency incentive was available in 2018-2019 and 2019-2020.
Southern Water	£790 dual services	£565	110 l/p/day	Part of Southern Water's Target 100 programme[9].
Severn Trent Water	£382 (clean water only)	100%	110 l/p/day	Further discount of £124 if no surface water connection is made to a public sewer, or £93 if the surface water connects to a public sewer via a sustainable drainage system (SuDS)[10].
Essex and Suffolk Water (Northumbrian Water Limited)	Not specified	100%[11]	105 l/p/day	Take up has been low due to lack of developer awareness[12].

While these types of incentive are likely to have encouraged developers to consider RWH and GWR as potential options to reduce water consumption in new buildings anecdotal evidence suggests take up has been limited as the water efficiency targets can generally be met via the installation of water efficient fixtures and fittings. In addition, the level of incentive only offsets a small proportion of the additional capital costs associated with RWH and GWR systems, which also require maintenance throughout the lifespan of the asset. This was highlighted by other water companies where infrastructure charges are low. For example, Thames Water whose charges are around £350/dwelling suggest that *"….discounts offer little incentive to drive uptake of these technologies"*[13]. Finally, a single scheme covering all water

[8] *If another water company provides the water or sewerage services, the refund would not be applicable to that company's charges for network reinforcement.
[9] https://www.southernwater.co.uk/media/2227/t100_acttoday.pdf
[10] https://www.stwater.co.uk/building-and-developing/regulations-and-forms/application-forms-and-guidance/infrastructure-charges/
[11] https://www.eswater.co.uk/globalassets/customer-pdfs/developer-pdfs/esw/infrastructure_charges_guidance_v1_october_2018_south.pdf
[12] Pers comm (Thomas Andrewartha)
[13] Pers comm (Thames Water)

companies rather than different schemes within water company boundaries would better suit larger developers operating nationally.

2.3 Market barriers

While rainwater harvesting and grey water recycling equipment sectors have become established, neither technology has become mainstream in new developments in the UK. According to industry stakeholders this has primarily been the result of a combination of factors including:

- Capital cost:
  - The low unit price (£/m^3) of water in the UK and relatively high capital cost of installation lead to long payback periods particularly on small scale installations and retrofits thus investments are often not considered financially viable.
  - Developers are not willing to invest as the CAPEX is not reflected in the selling price of the properties.
  - Information on installation costs, potential savings and hence payback was not available and/or not considered robust.
- Absence of specific policy and regulatory drivers. In particular the withdrawal of the Code for Sustainable Homes in 2015.
- Lack of customer demand / interest particularly for GWR systems. This is in stark contrast to other measures that reduce CO_2 emissions such as solar panels[14].
- The actual performance of existing systems is poorly understood and the wider benefits are often not clear. There is currently a lack of monitoring of existing systems and general information and guidance.
- The technologies are not feasible in all applications and are dependent on the amount of rainwater or grey water that can be collected (yield) and demand within the building.
- Disruption during installation and location of tank. In particular, when considering the retrofit of systems in existing buildings. In a 2019 report on public perceptions Waterwise reported that people were "*concerned about the upheaval of installation, and the idea that getting either system installed would be complicated and disruptive"* (Waterwise, 2019).
- Requirement for the system to be maintained including:
  - The cost of maintenance.
  - Lack of ownership/business models for maintenance (developers tend to want to sell and move on rather than be saddled with legacy associated with ownership and maintenance requirements)[15,8,13]
  - Lack of skills, expertise and knowledge base.
  - User behaviour e.g. switching to mains supply when there is an issue or fault.
- Public perceptions around water quality. In a recent survey Waterwise (2019) reported that *"People preferred the idea of a rainwater harvesting system to a grey water harvesting system. This is likely due to the perception of rainwater as being relatively 'clean' and 'pure' versus grey water, which was viewed as less clean, or sometimes as contaminated".*

As a result growth within the sectors has been stifled over the last decade with the RWH sector witnessing some consolidation. As a consequence there is now greater emphasis on larger scale projects at the development phase (e.g. community projects, non-domestic installations and multi-purpose developments) where the return on investment is often more favourable. There has also been a move away from small scale domestic installations and retrofits.

In addition, and in recognition of the tighter and long-standing regulations relating to sustainable drainage in new developments the RWH sector has repositioned itself more towards storage of water

[14] Pers Comm (Redrow)
[15] Pers comms (GLA)

for reuse. This better aligns the sector with the flood risk agenda and the wider benefits which may be achieved.

2.4 International policies and incentives

In contrast to experience in the UK the prevalence of RWH and GWR systems in many other countries is much higher. In particular, where governments and local/regional authorities have under a legal framework, with financial incentives (subsidies, reductions or tax refunds) promoted measures for the installation and use of rainwater and RWH systems.

For example, some form of RWH is mandatory for buildings and houses in various cities and states of Germany (Hessen, Baden-Württemberg, Saarland, Bremen, Thuringen, Hamburg); Spain; Belgium; in new buildings of some states of the USA (Tucson, Arizona, New Mexico); in for newly constructed buildings in Seoul, South Korea; and in Malaysia only for large buildings such as factories, schools etc. It is also mandatory in some Australian states, such as South Australia, New South Wales, and Queensland, where regulations stipulate a new rainwater collection system or alternative water source.

The findings of a targeted review of the policy options and interventions adopted to encourage the uptake of RWH and GWR systems in Germany, Australia, Japan and United States was undertaken and is presented below.

2.4.1 Germany

Often seen as leading the way in Europe in the use of RWH and GWR systems it is reported that almost one third of new buildings built in Germany in 2017 were equipped with a rainwater collection system for non-potable uses (mainly for irrigation, toilet flushing, and laundry use) (Campisano et al.,2017). However, water scarcity and the need to augment mains water supply are not the only drivers behind the market in Germany, with rainwater retention to control the frequency, peaks and volumes of urban runoff also featuring. Therefore specific policies and regulations supporting the decentralized management of rainwater harvesting and utilization of rainwater, have been increasingly applied during the last few decades and have contributed significantly to the increasing application and development of the sector (Yannopoulos et al., 2019).

A major element in the support of decentralized RWH systems is to provide certainty to all stakeholders, including the users, the installers and the operators of both the decentralized as well as the centralized drinking water supply and sewage discharge systems, with which the decentralized technologies have to be combined. Regulations, which provide clear rules, have been very effective in supporting the installation of decentralized systems.

A key milestone was the successful introduction of RWH systems in to German Industrial Standards (DIN); the DIN 1989 RWH Systems, the DIN 1986 Rainwater Pipes and, the DIN 1988 Drinking Water Installation, which provide the regulatory framework for the planning, installation, maintenance and operation of RWH systems (Schuetze 2013). While the installation of RWH systems is not generally required by state building codes, a regulation has been included in some areas including Hamburg, Bremen and Saarland.

In addition to the legal requirements and environmental concerns, financial incentives have also been used to encourage the construction of rainwater harvesting systems. In some federal states and municipalities subsidy programmes support the installation of decentralised systems:

- The State of Bremen provides a subsidy up to 12,000 Euros or a maximum of one third of the total investment costs for the installation of RWH systems in existing properties[16].

[16] https://climate-adapt.eea.europa.eu/metadata/case-studies/rainwater-saving-and-use-in-households-bremen

- In Schleswig-Holstein the construction of facilities for rainwater utilization and infiltration are financially supported by means of loans with low interest rates and a contract period of 25 years in the framework of their social housing program 'ownership measures'.

Specific tariff structures for potable water supply and sewage discharge fees based on volume, also mean that where systems are installed considerable financial savings can be achieved although in some areas it is noted that unit charges have reduced over the last decade[17].

Further to this around 30% of municipalities calculate their wastewater charges on a split tariff i.e. the fees are calculated separately for wastewater and rainwater which encourages rainwater harvesting (OECD, 2012). The 'rainwater tax' is based on the impervious surface of a property which drains water into the public sewage system. Collecting rainwater will therefore reduce sewage costs, and also improve the functioning and effectiveness of wastewater treatment network in case of a storm. In the city of Dresden, stormwater fees amount to 1.04 €/m^2/year. The revenue collected is used to finance collective projects aimed at promoting reuse of rainwater for municipal use or the organisation of promotion campaigns for the use of source control techniques (Acteon, 2010).

In contrast to RWH there is little evidence of any regulatory or financial incentives that encourage the uptake of GWR systems in Germany. The primary driver for the installation of GWR appears to be environmental although financial benefits can also be gained. As a result of the self-build nature of the construction industry in Germany, about 95% of the supplied systems are installed in single and double-family households with a treatment capacity of about 600 litres a day (The College for Estate Management, 2013).

The regulatory framework specifies that all GWR have to be registered with the Health Office in order to guarantee that no cross connections exist with the drinking water network and that pipes are labelled according to regulations. The hygiene requirements for recycled grey water, which is primarily used for toilet flushing, are oriented towards the EU-Guidelines for Bathing Waters. The use of recycled grey water for irrigation purposes is currently minor (Nolde, 2005).

2.4.2 Australia

Australia has one of the highest levels of implementation of RWH systems globally. The primary intent of rainwater harvesting in urban areas is to supplement main water supplies and to manage urban stormwater runoff. In 2015, the Australian Bureau of Statistics reported that approximately 1.7 million households had rainwater tanks installed in their properties[18]. However, beyond the household scale, there is limited data on the use of larger scale RWH systems in Australia, which tend to be installed in public areas for the irrigation of gardens and sports grounds. The prevalence of these more large-scale systems increased considerably in the 2000s because of severe water restrictions as a consequence of the extreme drought conditions that persisted in south-eastern Australia for around 10 years (Campisano et al., 2017).

To address concern regarding water sustainability, the Australian Federal Government and many state governments have implemented regulatory mechanisms and incentives to support households to purchase and install rainwater harvesting systems. Developers in many states are required to install rainwater tanks in new properties to comply with regulation. In 2004, a regulatory framework was created to ensure the requirements for rainwater tank installation complied with the Building Code of Australia (BCA) and the National Health and Medical Research Council (NHMRC). This was focused on water tank structures and water quality parameters (Chirhakarhula et al., 2018).

Between 2009 and 2011, under the Water for Future Initiative (WFI), the Australian Federal Government introduced a rebate scheme for the purchase and installation of new rainwater harvesting or grey water systems for non-potable purpose. The National Rainwater and Grey water Initiative provided

[17] https://www.bwb.de/en/1712.php (accessed 20/05/2020)
[18] https://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/4610.02013-14?OpenDocument

households with a rebate of up to $500 per installation and during the period 14,625 rebates, equivalent of $7 million, were offered through the scheme (Australian Government, 2009).

In addition to the Federal Government rebate scheme, many Australian State governments have developed regulatory mechanisms to promote rainwater harvesting and grey water recycling systems (Table 2-3).

Table 2-3 Requirements for rebates on rainwater tank systems (amended from Chirhakarhula et al., 2018 and[19]).

State	Fund allocation
South Australia	Up to $1,000 granted by SA water to purchase and installation of rainwater tank for non-potable use. Program ended in March 2013.
Victoria	Rebates from $500 to $1,500 depending on the size of the rainwater tank. Program ended 30 June 2015. Rebate of up to $500 for a grey water permanent tank system that recycles wastewater from laundries and bathrooms for toilet or garden use.
New South Wales	Up to $1,500 for tanks not installed under the BASIX regulation. Up to $500 offered by Sydney Water to schools to purchase tanks with an extra $500 to get them plumbed in for non-potable use. Program ended 30 June 2009.
Queensland	Rebates up to $1500 for a 3000 L tank or larger if plumbed in for non-potable use. Program ended 31 December 2008
Western Australia	A rebate up to $600 for tanks larger than 2,000 L if plumbed in for non-potable use. Program ended 30 June 2009
Australian Capital Territory	From $750 to $1,000 for new tanks if plumbed in for non-potable use. $600 to plumb in an existing tank. Program ended in 2008
Tasmania	In Hobart, up to $170 for outdoor use, $220 if plumbed in for non-potable use for tanks of at least 600 L capacity. Program ended 30 June 2008
Northern Territory	$500 rebate for rainwater tank or grey water diversion device. Rebate only available until funds run out.

In addition to the rebate schemes outlined above in some states municipal water companies also offer discounts on stormwater charges to encourage the collection and use of rainwater within the property. For example, Sydney Water offer a reduction in fixed quarterly stormwater charges from $19.83 to $6.19 against the installation of a rainwater tank. Further to this low impact discounts on stormwater charges for businesses for the collection and reuse of stormwater from non-domestic properties. This also extends to other on site water efficiency initiatives including grey water treatment and reuse[20].

2.4.3 Japan

Since the mid-1980s, particular importance has given to RWH in most Japanese cities and municipalities. Following the drought in 1994 and Great Hanshin-Awaji earthquake in 1995, a large number of municipalities re-evaluated RWH and tried to identify alternative water resources as a means to prevent urban flooding and to secure emergency water for disaster responses. The issue was regulated by ordinance and guidelines according to the local conditions (Yannopoulos et al., 2019).

[19] https://hipages.com.au/article/cash_rebates_for_water_savers
[20] https://www.sydneywater.com.au/SW/accounts-billing/understanding-your-bill/prices-for-your-business/index.htm

In 2001, a survey by the Association for Rainwater Storage and Infiltration Technology suggested that 208 municipalities were implementing subsidy programs for the establishment of facilities for storing or filtration systems of rainwater, and of these, 179 provide subsidies for installation of rainwater tanks (Japan for Sustainability, 2014). Sumida Ward was the first ward in Tokyo to promote the utilization of rainwater with subsidies providing half of the cost of rainwater tanks (up to 40,000 yen) including installation costs, on rainwater tanks with a capacity of less than 1,000 liters (Japan for Sustainability, 2014). As a result the installation of small-sized RWH systems with a storage capacity less than $1m^3$ is widespread in individual houses.

In 2015, an Act to Advance the Utilization of Rainwater was introduced. Under this act, municipalities are obliged to make their best effort to define and work toward rainwater utilization targets, while the national government is required to grant financial support for subsidy programs. These arrangements are expected to provide a nationwide move to promote rainwater use (Japan for Sustainability, 2014 and 2015).

On 10 March 2015, based on the above act, the Japanese government approved the wider usage of RWH systems in newly constructed buildings by the state government or incorporated administrative agencies, aiming for a 100% installation rate (Yannopoulos et al., 2019). Rainwater utilization is also now flourishing in the non-domestic sector. An early system installed in Tokyo's Sumo Stadium proved so successful that the city eventually required underground rainwater tanks for all new buildings, including the Skytree, Japan's tallest building (194). Over a thousand Tokyo buildings now harvest and recycle rainwater (194).

In Japan, the government does not provide incentives for household residents to install GWR systems. However, 70% of Japanese support the utilization of rainwater or recycled water as there is high awareness of the need to conserve water, and water costs are relatively high in urban areas (Yi-Kai Juan et al., 2016). In Tokyo, it is mandatory to install a grey water recycling system for a building with an area of over $30{,}000m^2$ or with potential non-potable demand of $100m^3$ per day (The College for Estate Management, 2013).

2.4.4 United States

In the United States rainwater harvesting is not currently regulated by the federal government and it is up to the individual states to regulate its collection and use (US Department of Energy, 2015). State level regulations and policies vary considerably and while the majority of states have no rainwater harvesting regulations in place some states provide specific incentives to encourage the collection of rainwater (US Department of Energy, 2015), for example[21]:

- Arizona: Rainwater harvesting is mandatory in new buildings of Tucson.
- California: The Rainwater Capture Act (2012) authorises residential, non-domestic and governmental landowners to install, maintain, and operate RWH systems.
- Florida: Tax incentives and rebates offered by several local municipalities to encourage the uptake of rainwater harvesting systems.
- New Jersey: Establishes Capture, Control, and Conserve Reward Rebate Program pending 2014. This bill will establish several incentives for installation and operation of a rainwater capture system and prohibiting any fees or taxation related to the purchase, installation and use of these systems.
- New York: Amends the tax law are currently pending (2016) to add a tax credit (up to 50 percent of the construction cost, not exceeding $5,000) for homeowners and businesses who invest in

[21] https://www.ncsl.org/research/environment-and-natural-resources/rainwater-harvesting.aspx

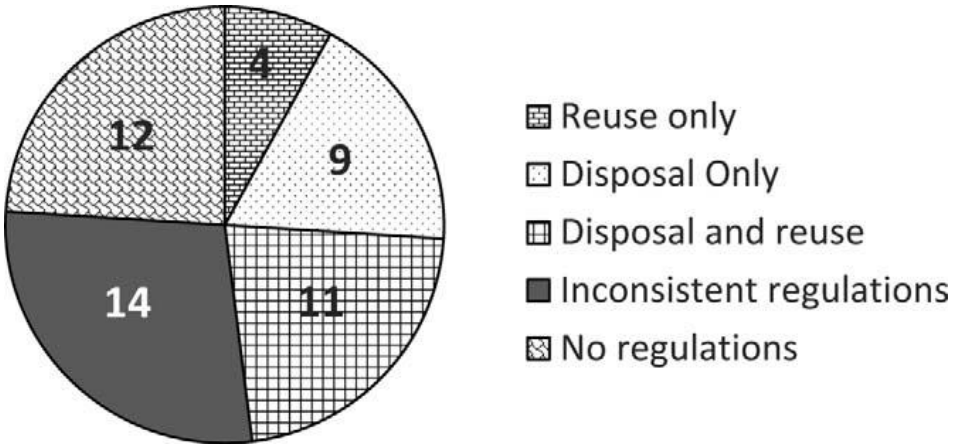
green infrastructure. Includes rainwater harvesting, raingardens, permeable pavements and green roofs as possible green infrastructure investments.

- New York: Water Conservation and Reuse Grant Pilot Program (NYC Environmental Protection, 2019) provides non-domestic, industrial, and multi-family residential property owners with incentives to install fixture retrofits and other water efficiency technologies, such as on-site water reuse systems. Buildings with successful on-site water reuse systems are eligible for a 25% water and wastewater fee discount[22]
- Rhode Island: Rhode Island House Bill (2012) created a State tax credit for rainwater systems. Any individual or business that installs a cistern on their property to collect rainwater for use in their home or business is entitled to a state income tax credit of 10 percent of the cost of installing the cistern not to exceed $1,000. Each entity is allowed only one tax credit over the life of the cistern unless they are replacing an existing cistern with a larger cistern and have not received the maximum tax credit of $1,000. A cistern is defined as a container holding fifty or more gallons of diverted rainwater or snow melt, either above or below ground.
- Texas: sales-tax free rainwater systems, tax incentives, and some local rebates. It is also mandatory for rainwater harvesting systems to be incorporated into the design of new state buildings with a roof measuring at least 50,000 square feet that is in an area of the state in which the average annual rainfall is at least 20 inches[23].
- Virginia: Senate Bill 1416 (2001**)** establishes the Alternative Water Supply Assistance Fund, which provides an income tax credit to individuals and corporations installing rainwater harvesting systems. However, money has not been allocated for these purposes.
- Washington: Allows counties to reduce rates for stormwater control facilities that utilize rainwater harvesting. Depending on the county, rates may be reduced by a minimum of 10% percent or more for any new or remodeled non-domestic building reduces surface and stormwater fees by 50%.

Similar to the collection and use of rainwater, there are currently no national guidelines in place regarding grey water reuse and individual states are responsible for its governance. Existing regulations and plumbing codes in the different states suggest that there are impediments to overcome but also potential incentives for grey water reuse. As of 2013, only around half of the states promoted the safe use of grey water in its regulation (Figure 2-2).

[22] https://www1.nyc.gov/site/dep/water/water-conservation-reuse-grants.page
[23] http://www.twdb.texas.gov/innovativewater/rainwater/index.asp

Figure 2-2 – States allowing grey water reuse and its disposal (Yu et al., 2013).



The key areas highlighted for concern are the acceptability of grey water segregation as a separate wastewater stream, allowable grey water storage, onsite treatment requirements, and permitted grey water use applications (primarily for outdoor irrigation with limited indoor use permitted)(Yu et al., 2013).

Despite these concerns, municipalities and counties in California are offering rebates and incentives for property owners who install grey water systems to irrigate their landscapes:

- Valley Water: Grey water 'laundry to landscape' rebate programme offers up to $400 for properties that connect their washing machine to the 'laundry to landscape system[24].
- Scotts Valley Water District: $150 rebate for residents that install a converted to allow grey water to be used for garden irrigation.
- Soquel Creek Water District: A rebate of $400 per 'laundry to landscape' system and up to $1,000 per household for a dual plumbed system for outdoor irrigation. The rebate applies to single or two-unit residential buildings only.

Further to this in Arizona, Tucson Water is offering a rebate of half the qualifying costs (up to $1,000) for residential grey water systems for outdoor irrigation (Figure 2-3). The rebate covers the design costs, materials, storage tanks, filters, pumps, backflow prevention assembly, and installation (Tucson Water, 2011)[25].

[24] https://www.valleywater.org/graywater-rebate-program
[25] https://www.tucsonaz.gov/water/gray-water-rebate

Figure 2-3 Marketing information promoting the Tuscon Water rebate scheme

2.5 Compilation of policy instruments and incentives

In considering the policies and incentives adopted in other countries and the current regulatory framework in the UK, a number of potential policy scenarios which could be adopted to encourage the uptake of RWH and GWR systems in this country start to emerge. These options have different characteristics which relate to:

- The compliance (whether the scheme is voluntary or mandatory e.g. law/regulatory changes).
- The governance of the scheme (whether the scheme is led by the Central, Local or Devolved Government, the utility company or developer).
- Scope of the scheme (Building type, residential, non-domestic, new developments, retrofit and scale).
- The availability of incentives (e.g. taxes, subsides, rebates and grants etc).

The above characteristics potentially lead to multiple different combinations of policy options. However, in practice, the governance and compliance options actually only represent six discrete options[26], which can be applied to different audiences and scenarios.

A further consideration in proposing sound policy options is Ofwat's duty on resilience which states[27]:

"Customers want confidence that clean, safe drinking water will be reliably available and that they can rely on their wastewater being taken away. Society needs confidence that these services will be provided today and in the long term, without compromising the natural environment, and more widely that decisions taken today will not impoverish future generations.

The Water Act 2014 adds a new duty to our primary duties: to 'further' the resilience objective (in England and Wales). It highlights the need for long-term resilience of water and wastewater systems and service provision when faced with increasing external stresses, such as environmental pressures, population growth and changes in consumer behaviour. It also highlights the need to:

- *promote long-term planning and investment, and the use of a range of measures to manage water resources in sustainable ways; and*
- *increase efficiency in water use and reduce demand for water to minimise pressure on water resources."*

[26] Mandatory or voluntary options which are central or local government or industry led.
[27] https://www.ofwat.gov.uk/regulated-companies/resilience-2/

The document highlights that in countries where RWH and GWR have become mainstream the sectors are underpinned by a strong regulatory framework. Uptake is then often further incentivised through the use of subsidies, rebates and loans to offset a proportion of the capital costs required for installation.

In the UK stakeholder feedback suggests the Buildings Regulations to be one of the most effective drivers for uptake alongside local planning policies which are helping to drive SuDs and RWH in new non-domestic buildings (Waterwise, 2020). Further to this financial incentives to reduce payback periods on initial investments and a reduction in the unit price of water supply charges post installation, would also be successful in encouraging uptake. Based on this review an initial long list of potential policy options which could be adopted in the UK and the incentives to support these is presented in Table 2-5 and Table 2-6.

Table 2-5 Potential policy options to encourage the uptake of RWH and GWR systems in the UK

a) Domestic Planning and Regulation

Ref	Options	Mechanism	Governance	Compliance
D1	LPA requirement for new developments to be built to <100 l/p/day	Local Plans & national policy guidance (NPPF)	LPA	Mandatory
D2	National requirement for new developments to be built to <80 l/p/day	Buildings Regulations	Government	Mandatory
D3	National requirement for installation of RWH in all new developments	Buildings Regulations	Government	Mandatory
D4	LPA requirement for installation of combined (RWH/GWR) in all new developments in specific geographic region(s)	Local Plans & national policy guidance (NPPF)	LPA	Mandatory
D5	LPA requirement for installation of RWH in all new developments in specific geographic region(s)	Local Plans & national policy guidance (NPPF)	LPA	Mandatory
D6	National requirement for all new developments to reuse a proportion of its water consumption.	Buildings Regulations	Government	Mandatory
D7	LPA requirement for SUDs /stormwater attenuation schemes to be designed with RWH in new developments.	Local Plans & national policy guidance (NPPF)	LPA / LLFA	Mandatory
D8	LPA requirement for a proportion of the SUDs capacity to be used to reduce overall development water demand.	Local Plans & national policy guidance (NPPF)	LPA / LLFA	Mandatory
D9	National requirement for retrofit of RWH in domestic buildings	Buildings Regulations	Government	Mandatory
D10	National requirement for retrofit of RWH in domestic buildings in specific geographic region(s)	Buildings Regulations	Government	Mandatory
D11	National requirement for the installation of a water reuse system in all new developments	Buildings Regulations	Government	Mandatory
D12	National requirement for installation of GWR in all new developments	Buildings Regulations	Government	Mandatory

b) Non-domestic Planning and Regulation

Ref	Option	Mechanism	Governance	Compliance
C1	National requirement for installation of RWH in all new developments	Buildings Regulations	Government /LPA	Mandatory
C2	LPA requirement for installation of RWH in all new developments over a certain size.	Local Plans & national policy guidance (NPPF)	LPA	Mandatory
C3	LPA requirement for installation of RWH in all new developments over a certain size in specific geographic region(s)	Local Plans & national policy guidance (NPPF)	LPA	Mandatory
C4	National requirement for all new developments to reuse a proportion of its water consumption.	Buildings Regulations	LPA	Mandatory
C5	LPA requirement for SUDs /stormwater attenuation schemes to be designed with RWH in new developments.	Local Plans & national policy guidance (NPPF)	LPA / LLFA	Mandatory
C6	LPA requirement for a proportion of the SUDs capacity to be used to reduce overall development water demand.	Local Plans & national policy guidance (NPPF)	LPA / LLFA	Mandatory
C7	National requirement for installation of GWR in all new non-domestic residential buildings.	Buildings Regulations	Government /LPA	Mandatory
C8	LPA requirement for installation of GWR in all new non-domestic buildings with high non-potable water demand.	Local Plans & national policy guidance (NPPF)	LPA	Mandatory
C9	LPA requirement for installation of GWR in non-domestic buildings with high non-potable demand in specific geographic region(s).	Local Plans & national policy guidance (NPPF)	LPA	Mandatory
C10	National requirement for retrofit of GWR in existing non-domestic residential buildings in specific geographic region(s).	Buildings Regulations	Government	Mandatory
C11	National requirement for retrofit of GWR in existing non-domestic buildings with high non-potable demand.	Buildings Regulations	Government	Mandatory
C12	National requirement for the installation of a water reuse system in all new developments	Buildings Regulations	Government	Mandatory

c) Options for the Government Estate

Ref	Option	Mechanism	Governance	Compliance
G1	National requirement for retrofit of RWH in all public buildings.	Property policy / Government Estate Strategy	Central / Local Government	Mandatory
G2	National requirement for retrofit of RWH in all public buildings over a certain size.	Property policy / Government Estate Strategy	Central / Local Government	Mandatory
G3	National requirement for retrofit of RWH in all public buildings over a certain size in specific geographic region(s).	Property policy / Government Estate Strategy	Central / Local Government	Mandatory
G4	National requirement for retrofit of GWR in existing buildings with high non-potable demand.	Property policy / Government Estate Strategy	Central / Local Government	Mandatory
G5	National requirement for retrofit of GWR in existing buildings with high non-potable demand in specific geographic region(s).	Property policy / Government Estate Strategy	Central / Local Government	Mandatory
G6	National requirement for the installation of a water reuse system in all new public buildings	Property policy / Government Estate Strategy	Central / Local Government	Mandatory

d) Voluntary programmes and schemes (BREEAM)

Ref	Option	Mechanism	Governance	Compliance
V1	Behaviour change campaign to encourage uptake of RWH. Including the provision of technical guidance and case studies.	Marketing campaign	Government	Voluntary
V2	Increase BREEAM[28] credits for installation of RWH in new buildings	BREEAM	Construction industry	Voluntary
V3	Increase BREEAM credits for installation of GWR in new buildings	BREEAM	Construction industry	Voluntary
V4	Extend existing schemes (e.g. BRE Home Quality Mark) to include the installation of RWH or GWR.	HQM or similar	Construction industry	Voluntary

[28] BREEAM is a sustainability assessment method for new buildings and infrastructure

Table 2-6 Potential incentives and fiscal drivers to encourage the uptake of RWH and GWR systems in the UK

a) Subsidy and rebate programmes

Ref	Option	Mechanism	Governance	Compliance
SR1	National rebate scheme to promote uptake of RWH and GWR systems for non-potable use in domestic properties. Rebate of £1,000 per installation.	Rebate programme	Government / water company	Voluntary
SR2	National rebate scheme to promote uptake of RWH systems for non-potable use in domestic properties. Rebate of £1,000 - £2,500 per installation depending on size of rainwater tank.	Rebate programme	Government	Voluntary
SR3	Zero tax on installation of RWH and GWR systems for non-potable use in domestic properties.	Sales tax (VAT)	Government / HM Treasury	Voluntary
SR4	Regional subsidy of up to £2,500 for the installation of RWH system in for non-potable use in schools	Rebate programme	Water company	Voluntary
SR5	Regional rebate scheme to promote uptake of RWH and GWR systems for non-potable use in domestic properties. Rebate of £500 per installation.	Rebate programme	Water company	Voluntary

b) Water company charges

Ref	Option	Mechanism	Governance
WC1	Introduction of regional tariffs. Increase unit price of water supply and wastewater discharge (p/m^3) in specific geographic region(s).	Water company charges	Water industry / Ofwat
WC2	Reduction in unit cost of water supply (p/m^3) for sites with operational RWH or GWR system in place	Water company charges	Water industry / Ofwat
WC3	Extension and harmonisation of site area based charges for surface water drainage.	Water company charges	Water industry / Ofwat
WC4	Introduction of surface water discharge levy for large non-domestic sites.	Water company charges	Water industry / Ofwat
WC5	Extend surface water drainage rebates to domestic customers with RWH system installed.	Water company charges	Water industry / Ofwat
WC6	Waiver of connection charges for developments with individual RWH system or communal RWH systems installed.	Water company charges	Water industry / Ofwat

2.6 Screening of policy options

The long list of policy options and incentives presented in Table 2-5 and Table 2-6 were screened to produce a short list of options for subsequent modelling to assess the cost and benefits and impacts on per capita consumption (PCC), non-domestic water usage and the zero carbon agenda.

For the screening process a qualitative assessment of each policy option was undertaken through a multi-criteria analysis (MCA)-like process with each option scored (from -3 (major negative) through 0 (neutral), to +3 (major positive)) against the set of criteria outlined in Table 2-7. The results from the MCA are provided in Appendix 2.

Table 2-7 Overarching criteria for short listing process

Criteria	Points considered
Effectiveness in driving take up.	- Will the option drive the uptake of RWH and GWR technologies in the market; - The strength of the driver. - Will it drive the uptake of other technologies? - Can it be applied nationally / regionally
Speed of take up.	- How quickly can the option be introduced? - Are there any barriers to the option being introduced? - How quickly can the measures be installed?
Ability to drive take up across all households/ building types.	- Applicability across all sectors i.e. household, non-domestic etc - Applicability across different building types.
Efficiency of take up – i.e. does it drive take up of most cost-effective techniques.	- Will it drive the take up of RWH and GWR systems? - Will it drive the uptake of other technologies?
Acceptability – linked to impacts on businesses/households/developers.	- Is the technology acceptable to the end customer? - Consumer perceptions around the technology. - Will the option cause disruption?
Feasibility / deliverability.	- Is the option technically feasible? - How difficult it would be to introduce? - Are any of the risks and uncertainties unacceptable and likely to result in failure of the option?
Scale of impact.	- Size of market and scale of savings - large number of small potential savings versus small number of large potential savings. - Domestic and non-domestic, national or regional.

Following completion of this screening stage a short list of policy options has been developed based on the MCA process. Further consideration was also given to the overall coverage of the technologies, building types and policy framework (national versus local) to ensure balance. Where appropriate some policy options have been combined or consolidated. An overview of the short listed policy options is provided in Table 2-8.

During this stage, consideration was also given to the outputs from a separate cost benefit analysis of RWH and GWR systems which highlighted the cost-effectiveness of the technologies at different scales (Waterwise, 2020).

Table 2-8 Short list of policy options

Ref	Option	Assessment
P1	National requirement for new developments to be built to <80 l/p/day.	Previously D2
P2	National requirement for installation of RWH in all new developments.	Combined C1 and D3
P2.1	- LPA requirement for installation of RWH in all new developments over a certain size.	Previously C2
P2.2	- LPA requirement for installation of RWH in all new developments in specific geographic region(s).	Previously D5
P2.3	- LPA requirement for installation of RWH in all new developments over a certain size in specific geographic region(s).	Previously C3
P3	LPA requirement for SUDs /stormwater attenuation schemes to be designed with RWH in new developments.	Combined C5, C6, D7 and D8
P4	LPA requirement for installation of GWR in all new non-domestic buildings with high non-potable water demand.	Previously C8
P4.1	- LPA requirement for installation of GWR in all new non-domestic buildings with high non-potable demand in specific geographic region(s).	Previously C9
P5	National requirement for retrofit of RWH in all public buildings.	Previously G3
P5.1	- National requirement for retrofit of RWH in all public buildings over a certain size.	Previously G4
P5.2	- National requirement for retrofit of RWH in all public buildings over a certain size in specific geographic region(s).	Previously G5
P6	National requirement for the installation of a water reuse system in all new developments.	Previously D11 and C12
P7	Behaviour change campaign to encourage uptake of RWH. Including the provision of technical guidance and case studies.	Previously V1

Ref	Option	Assessment
P8	Extend existing schemes (e.g. BREEAM, BRE Home Quality Mark) to include the installation of RWH or GWR.	Combined with V2, V3 and V4

The final short list of policy options formed the basis of an assessment of the cost and benefits and impacts to PCC, non-domestic water usage and the zero carbon agenda (see Section 3). Each policy option in Section 3 was assessed based on the impacts set out in the cost benefit analysis which was reported separately (Waterwise, 2020), these include:

- CAPEX and OPEX associated with installation
- Water usage
- The carbon involved in installation and maintenance
- The impact on (current and future) water infrastructure
- Potential reduction of flood impacts and connection with SUDs.

Section 3 also sets out the assumed effectiveness of the policies (where uptake is voluntary) and includes a sensitivity test around these parameters. Where policy options call for implementation in specific regions, there is a focus on those deemed most water stressed and how RWH and GWR can alleviate this. Finally, the carbon impact of the options and how the policies contribute to a low carbon agenda was also considered.

3 Modelling policy options to assess the cost and benefits and impacts to PCC, non-domestic water usage and the zero carbon agenda

3.1 Introduction

This task seeks to provide an insight, by way overall water savings alongside the costs and benefits, to the short list of policy options developed in Section 2.6. It is also supplemented and supported by a discussion of how RWH and GWR can support a zero carbon agenda in the water industry. The costs and benefits associated with the installation of a single RWH or GWR system in a building of size X (determined by the collection area and water demand or yield) have been determined separately (Waterwise, 2020). A summary of the results from this cost and benefits analysis is provided in Appendix 1. These cost benefit analyses (CBAs) form the basis of the analysis undertaken in this section and the reader should refer to the Waterwise report for further detail.

The main task outlined in this section is to quantify the impacts of the short listed policies and estimate the number of installations that could arise as a result. The short listed policy options are split between policies that focus on requirements for new builds and requirements to retrofit certain buildings. Building estimations have therefore been focused on determining the total number of buildings in England and Wales and the number of new buildings built annually.

Determining the number of new and total domestic buildings in England and Wales

NOMIS[29] provides information, based on UK Census data, on the number of dwellings, by region, in England and Wales (as shown in Appendix 3 – Section A3.1). From this a scaling factor has been applied to estimate the total number of unique buildings, in the case of multiple dwellings in a single buildings i.e., blocks of flats.

The Office for National Statistics produces statistics on the number of new dwellings completed every year[30]. This provided the total number of new dwellings, the split by region and building type provided by NOMIS was applied to this total number in order to provide an estimate breakdown of new buildings.

Determining the number of new and total non-domestic buildings in England and Wales

The NOMIS data set on UK Business Counts[31] was used to develop estimates for the number non-domestic buildings in England and Wales and how many new buildings are built annually. The total number of business units in 2019 is used to determine the total stock of non-domestic buildings and the average change in the number of business units between 2013 and 2019 is used to estimate the number of new non-domestic buildings completed each year, split by region (shown in Appendix 3 – Section A3.1). This data was also available by business size, these were split into the following groups which allowed an estimate of the collection area, demand and yield of the buildings they resided in to be derived.

- Micro (0-9 employees)
- Small (10-49 employees)
- Medium (50 -249 employees)
- Large (250+ employees)

[29] https://www.nomisweb.co.uk/
[30] https://www.ons.gov.uk/peoplepopulationandcommunity/housing/datasets/ukhousebuildingpermanentdwellingsstartedandcompleted
[31] https://www.nomisweb.co.uk/sources/ukbc

Finally, it was recognised that each business was unlikely to reside in its own property, but also that it was more likely for a larger business than a smaller business. A scaling factor was therefore applied to estimate the total number of non-domestic buildings in an area.

3.1.1 Understanding the number of buildings impacted

The Office for National Statistics reported that 178,800 new dwellings were completed in 2019 in England, and 6,070 in Wales. By combining this with the current split of housing stock in England and Wales an estimated split of new dwelling types was produced (see Table 3-1).

Table 3-1: Total number of new unique dwellings and new business units (sites) in 2019

Domestic building	Number	Non-domestic	Number
Detached houses	43,487	Micro (0-9 employees)	86,013
Semi-detached houses	59,556	Small (10-49 employees)	5,348
Housing developments	47,683	Medium (50-249 employees)	1,036
Flats (purpose-built blocks)	31,633	Large (250+ employees)	123
Flats (converted non-domestic buildings)	2,152		
Total	**184,780**	**Total**	**92,520**

Several assumptions were applied to these numbers to estimate the number of new RWH and/or GWR units that could be installed, at what size and therefore the total costs, benefits and water savings.

- Firstly, it is assumed that half of all new built houses are built as part of domestic developments and that a single large system or network is installed across multiple properties.
- Secondly, it is assumed that, on average, there are 30 new dwellings in a new built block of flats and 10 flats in converted non-domestic buildings.
- For non-domestic buildings, it is assumed that each new business does not exist in its own dwelling and that smaller business are likely to share a dwelling with a larger number of other businesses, a scaling factor has therefore been used to estimate the total number of dwellings.
- Despite the above assumption, the scaled number of non-domestic units is used to inform the estimated building size, and therefore collection area of the non-domestic building.
- The number of employees is used to estimate the size (physical space) of the business.
- Similar assumptions around domestic building type, size and number of occupants is used to map the building types to the collection area and demand bands reported in the cost benefit analysis. The exact relationship between building types and collection area and demand is set out in the Appendix 3– Section A3.2.

3.1.2 Impact on overall water demand

One of the key metrics for understanding the impact of the shortlisted policies is the impact on overall water demand (given in mega-litres per day; Ml/day) for both domestic and non-domestic properties. Estimates of current domestic and non-domestic water demand were developed based on data provided in the Artesia (2018) report: 'The long term potential for deep reductions in household water demand'. Current domestic and non-domestic water demand was modelled to be 8,421 Ml/day and 3,055 Ml/day respectively.

3.1.2.1 Domestic

Domestic consumption under each of the national shortlisted policy options has been modelled in relation to a business as usual (BAU) scenario. It is assumed that each policy option would be implemented by 2021 and provides an estimate of the water demand after 10 (2031) and 20 years (2041) of implementation (in Ml/day) based on a constant PCC of 140 l/p/d (Artesia, 2018) and a growing population (based on estimates provided by the ONS). It also assumes that no other PCC reductions occur over the same time period.

Policies that focus on specific geographical regions consider the possible water reductions in the water stressed areas of the 'South East[32]' and have a PCC of 146 l/p/day (calculated based on a 2018 Artesia report as illustrated in Figure 3-1 and Table 3-2).

Figure 3-1: PCC by region (Artesia 2018)

Table 3-2: Assumed per capita consumption in 2021 (Artesia, 2018)

Area	PCC
England and Wales	140
South East (including London, the South East and the East of England)	146

The water savings in each scenario have been calculated by estimating the number of new developments over a 10 year period, calculating the water saving if the building had a re-use system installed (based on real world data) and subtracting this from the total water demand in the BAU scenario. The modelling accounts for all new domestic development over the appraisal period, this includes building new stock and the replacement of old housing stock, estimates of the annual number of domestic homes built is based on the NOMIS dataset[33]. A summary of the potential domestic water savings for each of the shortlisted policies is provided in Table 3-3.

[32] Based on the area designation of Artesia (2018), this includes the regions of England: the East, the South East and London, as defined by the Office of National Statistics. (215)
[33] https://www.nomisweb.co.uk/

Table 3-3: Modelled mega-litres/day reductions for shortlisted policies in domestic properties in England and Wales[34]

Policy	2031	2041
Business As Usual (BAU) – modelled total demand	8,769	9,049
P1: National requirement for new developments to be built to <80 l/p/day[35]	411	821
P2: National requirement for installation of RWH in all new developments.	411	822
P2.1: LPA requirement for installation of RWH in all new developments over a certain size.	232	463
P2.2: LPA requirement for installation of RWH in all new developments in specific (water stressed) geographic region(s).	173	346
P2.3: LPA requirement for installation of RWH in all new developments over a certain size in specific (water stressed) geographic region(s).	102	204
P3: LPA requirement for SUDs /stormwater attenuation schemes to be designed with RWH in new developments.	232	463
P4: LPA requirement for installation of GWR in all new non-domestic buildings with high non-potable water demand.	-	-
P4.1: LPA requirement for installation of GWR in all new non-domestic buildings with high non-potable demand in specific (water stressed) geographic region(s).	-	-
P5: National requirement for retrofit of RWH in all public buildings.	-	-
P5.1: National requirement for retrofit of RWH in all public buildings over a certain size.	-	-
P5.2: National requirement for retrofit of RWH in all public buildings over a certain size in specific (water stressed) geographic region(s).	-	-
P6: National requirement for the installation of a water reuse system in all new developments.	411	821
P7: Behaviour change campaign to encourage uptake of RWH. Including the provision of technical guidance and case studies	57	113
P8: Extend existing schemes (e.g. BREEAM, BRE Home Quality Mark) to include the installation of RWH or GWR.	149	298

3.1.2.2 Non-domestic water demand

A similar approach was taken to understand water demand in non-domestic buildings. The non-domestic water demand baseline was developed based on the assumption that non-domestic water consumption accounted for 20% of all water demand (Artesia, 2018). This was calculated to be 3,055 Ml/day. From this a business as usual scenario was developed based on the percentage increase in domestic water demand.

[34] Demand if for the geographic area covered by the policy, when policies only affect water stressed areas, demand is only for these areas.
[35] This policy assumes that all new buildings will need to be built 80l/p/day, however this is not achievable by installation reuse systems alone. The PCC numbers represent a national average of all buildings.

Non-domestic water savings were calculated by estimating the water savings from installing a water re-use system in all buildings targeted by the policy, and removing this from the total forecast water demand. The demand calculations account for new non-domestic development, this includes new buildings and the replacement of old non-domestic building stock. When assessing policies in targeted water stressed areas, these areas are assumed to use 1287 ML/day (Table 3-4)[36].

Table 3-4: Modelled mega-litres/day reductions for shortlisted policies in non-domestic properties in England and Wales[37]

Policy	2031	2041
Business As Usual (BAU) – modelled total demand	3,181	3,283
P1: National requirement for new developments to be built to <80 l/p/day	-	-
P2: National requirement for installation of RWH in all new developments.	223	447
P2.1: LPA requirement for installation of RWH in all new developments over a certain size.	85	172
P2.2: LPA requirement for installation of RWH in all new developments in specific (water stressed) geographic region(s).	146	292
P2.3: LPA requirement for installation of RWH in all new developments over a certain size in specific (water stressed) geographic region(s).	50	101
P3: LPA requirement for SUDs /stormwater attenuation schemes to be designed with RWH in new developments.	54	109
P4: LPA requirement for installation of GWR in all new non-domestic buildings with high non-potable water demand.	51	102
P4.1: LPA requirement for installation of GWR in all new non-domestic buildings with high non-potable demand in specific (water stressed) geographic region(s).	28	55
P5: National requirement for retrofit of RWH in all public buildings.[38]	184	368
P5.1: National requirement for retrofit of RWH in all public buildings over a certain size.	107	214
P5.2: National requirement for retrofit of RWH in all public buildings over a certain size in specific (water stressed) geographic region(s).	45	89
P6: National requirement for the installation of a water reuse system in all new developments.	221	443
P7: Behaviour change campaign to encourage uptake of RWH. Including the provision of technical guidance and case studies	33	67
P8: Extend existing schemes (e.g. BREEAM, BRE Home Quality Mark) to include the installation of RWH or GWR.	30	60

[36] This is calculated based on the known non-residential water demand in England and Wales and the percentage of residential water demand that occurs in water stressed areas.
[37] Demand if for the geographic area covered by the policy, when policies only affect water stressed areas, demand is only for these areas.
[38] This policy assumed that 50% of public buildings will be retrofitted in the first 10 years and 100% of public buildings will be retrofitted by 2041.

3.2 Analysing the short-listed policy options

Each of the short listed policy options have been analysed further to establish an estimate of the total impacts for each of the collection area and demand bands reported in the previous cost benefit analysis (Waterwise, 2020). A summary of the headline figures from this analysis is provided in the sections below with a more detailed breakdown given in Appendix 3 Section A3.3.

3.2.1 P1: National requirement for new developments to be built to <80 l/p/day

The overarching aims of introducing and increasing the use of RWH and GWR in new domestic developments is to reduce the overall consumption of mains water, down to a level of 80 litres per person per day. Increasing the use of either RWH or GWR would go part of the way to achieving this and is considered an essential element of meeting this target.

This analysis only considers the costs and benefits associated with installing either RWH or GWR in a new domestic building and not any other measures that might need to be retrofitted to reach 80 l/p/day. As these measures are unknown it would not be consistent to calculate the water savings of the additional measures without also including the associated costs. The contribution that introducing either a RWH or GWR system in to all new buildings would have on national PCC is shown in Table 3-5.

Table 3-5: Modelled impact on domestic water demand and PCC from implementing policy option P1

		2021	2031	2041
Domestic water demand				
Business as usual	Ml/day	8,421	8,769	9,049
Policy scenario P1	Ml/day	8,421	8,358	8,228
Per capita consumption				
Business As Usual	PCC	140	140	140
Policy Scenario P1	PCC	140	133	127

This policy would affect new domestic properties only (including the building of new stock and the replacement of old buildings) and it is also assumed that either RWH or GWR would need to be installed to achieve this (but not both).

The split between the percentage of total new builds that would install RWH and GWR harvesting has also been modelled. These estimates have been informed by the literature review, the perceived preference for RWH in current new builds and the underlying costs and benefits. Specifically, as GWR has a net cost for low and small demand properties (Waterwise, 2020), it is assumed that only a relatively small percentage of these buildings would install GWR. In larger buildings, the majority of new builds still install RWH, due to current trends, however GWR starts to become cost (and benefits) competitive and therefore a greater percentage will choose GWR. The modelled split across demands is shown in Table 3-6.

Table 3-6: Modelled percentage split between installing RWH and GWR in new builds to achieve 80 l/p/day

Water demand	RWH	GWR
Low	95%	5%
Small	90%	10%
Medium	85%	15%
High	75%	25%
Significant	60%	40%

Overall, installing either RWH or GWR as part of a collection of measures to reach 80l/person/day would have a net benefit despite the fact that installing GWR at the levels assumed results in a net cost. Despite the net cost for GWR, it is assumed that a small percentage of smaller developments would still choose to install it particularly if they were prohibited from installing RWH for some reason.

Moreover, the costs associated with GWR are entirely offset by the benefits seen from installing RWH in new builds. Overall almost £1.1 billion in net benefit per year of new builds across the lifetime of the installation, these benefits are calculated based on a net benefits per installation, set out in Waterwise, 2020, scaled up to reflect the number of buildings that a RWH/GWH system would be installed in (Table 3-7; Appendix 3 Section A3.3.1). This analysis does not take in to account certain economic factors that may occur given a policy of this scale, principally the economies of scale that would occur from a mass installation project. It is also worth reiterating that while a significant percentage is from reduced water demand and therefore reduced costs of water, this also includes indirect benefits including reduced damage from flooding and reduced stress of water and sewage systems. Nevertheless, analysis shows that reduced water costs for buildings would account for, on average 40% of the benefits for domestic buildings and 50% of the benefits for non-domestic buildings.

Table 3-7: Total impact of installing RWH or GWR as part of a national requirement to reach 80l/p/day in new domestic buildings

	Number of new buildings per year	Impact	Impact (millions)
Rainwater harvesting systems	68,219	£ 1,156,720,888	£ 1,157
Grey water recycling systems	3950	-£ 65,785,573	-£65
Total	72,169	£ 1,090,935,315	£ 1,091

3.2.2 P2: National requirement for installation of RWH in all new developments.

The requirement for all new developments to include a RWH system would be one of the widest impacting policies, requiring implementation at the national level and impacting all types of domestic and non-domestic buildings. The impact of the policy would have on domestic and non-domestic water demand is shown in Table 3-8.

Table 3-8: Modelled impact on domestic and non-domestic water demand from implementing policy option P2

		2021	2031	2041
Domestic water demand				
Business as usual	Ml/day	8,421	8,769	9,049
Policy scenario P2	Ml/day	8,421	8,358	8,227
Non-domestic water demand				
Business as usual	Ml/day	3,055	3,181	3,283
Policy scenario P2	Ml/day	3,055	2,958	2,836

Table 3-9 shows the total annual impact of installing RWH in all new developments. The analysis shows that over 77,000 RWH systems of various sizes would be installed each year and could have a net benefit of just over £3 billion over the 20 year lifetime of the system, a more detailed split of the impacts by building size and use is shown in Appendix 3 Section A3.3.3, Table A3-7.

Further analysis shows that installing RWH in all new domestic buildings would save almost £900 million in water bills over the lifetime of a RWH system (almost 21% of the total benefits accrued to the system),

with approximately £3.3 billion in wider savings included reduced flood risk damage and reduced spend on water infrastructure.

RWH systems in new non-domestic buildings would see over £200 million in water cost savings over 20 years (48% of the total benefit) and almost £215 million in wider societal benefits.

Table 3-9: Net impact of installing a RWH system in all new developments

Number of new buildings per year	Impact	Impact (millions)
77,102	£ 1,599,830,322	£ 1,600

3.2.2.1 P2.1: LPA requirement for installation of RWH in all new developments over a certain size.

One risk of the policy requiring RWH in all new developments is the significant impact that it could have on smaller new developments which may not see as much benefit or any pay back (analysis of the private costs and benefits shows that installations in smaller collection areas do not see a payback on water savings on the cost of the system over the 20 years).

An alternative policy could then be to require RWH on larger developments (including housing developments) to minimise the burden on smaller developments. This would still produce a significant reduction in overall water demand as shown in Table 3-10 and an overall net benefit, as shown in Table 3-11 (See also Appendix 3 Section A3.3.3 Table A3-8).

Table 3-10: Modelled impact on domestic and non-domestic water demand from implementing policy option P2.1

		2021	2031	2041
Domestic water demand				
Business as usual	Ml/day	8,421	8,769	9,049
Policy scenario P2.1	Ml/day	8,421	8,537	8,586
Non-domestic water demand				
Business as usual	Ml/day	3,055	3,181	3,283
Policy scenario P2.1	Ml/day	3,055	3,096	3,111

An assessment of the net economic benefit of requiring installation on sites with a collection area deemed ‘large’ or ‘very large’ (i.e., with a collection area over 2,000m^2) has been undertaken. This includes new housing developments, new blocks of flats and larger non-domestic buildings.

Table 3-11 Impact of installing RWH on 'large' and 'very large' buildings

Number of buildings	Impact	Impact (millions)
2,617	£ 567,976,088	£ 568

By limiting the policy requirement to only larger developments, the number of buildings/developments that would be required to install RWH would fall significantly (just over 10,000 compared to over 75,000 for all buildings). However, while this accounts for just 12% of all installations, the net benefits from this (£1.2 billion) accounts for 40% of the benefits accrued if installed on all buildings.

Moreover, when installations are limited to larger businesses around 34% of the benefit is private benefit is from water savings (£465 million over 20 years) and almost 50% of the benefits to non-domestic buildings is from water savings (£65 million over 20 years).

3.2.2.2 P2.2: LPA requirement for installation of RWH in all new developments in water stressed geographic region(s).

A more specific analysis considers the reduced water demand and overall impact of a policy that specifically targets the water stressed regions of the East of England, South East and London. The overall water reduction across this area is shown in TableTable 3-12.

Table 3-12: Modelled impact on domestic and non-domestic water demand from implementing policy option P2.2

		2021	2031	2041
Domestic water demand				
Business as usual	Ml/day	3,605	3,743	3,859
Policy scenario P2.2	Ml/day	3,605	3,570	3,513
Non-domestic water demand				
Business as usual	Ml/day	1,287	1,337	1,378
Policy scenario P2.2	Ml/day	1,287	1,191	1,086

Table 3-13 shows the overall financial impact of installing RWH in all new developments in the East, South East and London. Despite being restricted to a smaller geographic area this policy would still be significant, affecting almost 30,000 new domestic buildings annually. This would result in over £850 million in annual savings through reduced water bills for customers, less damage from flood and reduced spending on water infrastructure.

Table 3-13: Net benefit of requiring RWH in new developments in water stressed areas

Number of new buildings per year	Impact	Impact (millions)
29,191	£ 867,672,600	£ 868

3.2.2.3 P2.3: LPA requirement for installation of RWH in all new developments over a certain size in water stressed geographic region(s).

A potentially more cost effective approach would be to require RWH systems in all new developments over a certain size, assumed to be buildings or developments with a collection area over 2,000 m^2. Table 3-14 shows that limiting the requirement to larger buildings would still reduce domestic water use by almost 500 Ml/day and non-domestic use by 100 Ml/day.

Table 3-14: Modelled impact on domestic and non-domestic water demand from implementing policy option P2.3

		2021	2031	2041
Domestic water demand				
Business as usual	Ml/day	3,605	3,743	3,859
Policy scenario P2.3	Ml/day	3,605	3,641	3,654
Non-domestic water demand				
Business as usual	Ml/day	1,287	1,337	1,378
Policy scenario P2.3	Ml/day	1,287	1,286	1,277

Table 3-15 shows the overall financial impact of installing RWH in all new developments over 2,000 m^2 in water stressed geographic regions. While this would only affect around 1,226 new domestic

buildings annually it would result in over £284 million in annual savings through reduced water bills for customers, less damage from flood and reduced spending on water infrastructure.

Table 3-15: Net benefit of requiring RWH in new developments over a certain size in water stressed areas

Number of new buildings per year	Impact	Impact (millions)
1,226	£ 283,869,107	£ 284

3.2.3 P3: LPA requirement for SUDs /stormwater attenuation schemes to be designed with RWH in new developments.

A potential way to reduce the costs associated with RWH is to link it to the requirement for SuDs during construction. Here it is estimated that by linking RWH to SuDs at the time of construction a developer could reduce costs significantly, lowering the barrier to entry and increasing the payback.

In England, as SuDs is only required for 'major developments' over 10 domestic properties or an equivalent non-domestic development the analysis is limited to assume that RWH would only be installed in developments categorised as 'large' or 'very large', this means that their collection area is over 2,000m^2, and typically includes multi property domestic developments, blocks of flats or multi-unit non-domestic development. This would still have a significant impact on reducing both PCC and non-domestic water demand over the next 20 years (Table 3-16), by installing RWH in all buildings that require the installation of SuDs, 450 Ml/day could be saved from domestic demand and over 100 Ml/day form non-domestic demand by 2041.

Table 3-16: Modelled impact on domestic and non-domestic water demand from implementing policy option P3

		2021	2031	2041
Domestic water demand				
Business as usual	Ml/day	8,421	8,769	9,049
Policy scenario P3	Ml/day	8,421	8,537	8,586
Non-domestic water demand				
Business as usual	Ml/day	3,055	3,181	3,283
Policy scenario P3	Ml/day	3,055	3,127	3,174

This policy option is estimated to affect over 2,500 different developments a year and could see a net benefit of over £600 million over the lifetime of the installations. There is significant benefits to be achieved from installing RWH, particularly on the larger properties and the high demand properties where the flood damage reduction and the water savings can be significant (Table 3-17; Appendix 3 A3.3.5 Table A3-10). The focus on larger developments captures these benefits and the reduced costs associated with installation increase the net benefits further.

Table 3-17: Net impact of installing RWH systems linked to SuDs where SuDs is required[39]

Number of new buildings per year	Net impact (£)	Net impact (£ millions)
2,617	£ 611,323,291	£ 611

[39] Based on UK flood risk assessment data – see Appendix 3 Section A3.3.4

Overall, linking rainwater harvesting to SUDs is a very attractive policy option, as it significantly reduces the upfront costs and focuses deployment of the technology on the larger sites where they can achieve the most benefit, both through reducing water demand and providing flood damage reduction.

3.2.4 P4: LPA requirement for installation of GWR in all new non-domestic buildings with high non-potable water demand.

The cost benefit analysis highlights that GWR systems only have a net benefit where demand is over a certain size, approximately 1,500m^3 per year. This policy would therefore look at installing GWR in new non-domestic buildings where a net positive impact for the installation could be ensured.

The policy would target developments considered 'high' or 'significant', and is intended to reflect larger developments such as multi-story offices or large mixed-use (non-domestic and retail) developments, estimated to be around 330 developments a year. The relatively small number target buildings means that the net impact on non-domestic water demand is small (saving approximately 510Ml of water per day by 2041; Table 3-18).

Table 3-18: Modelled impact on non-domestic water demand from implementing policy option P4

		2021	2031	2041
Non-domestic water demand				
Business as usual	Ml/day	3,055	3,181	3,283
Policy scenario P4	Ml/day	3,055	3,130	3,181

Despite the small total water saving (at the national level), this policy is a relatively cost effective approach to reducing water demand in non-domestic buildings, as shown in Table 3-19. The benefit per installation (over its lifetime) for a high demand installation is approximately £68,000, where the potential benefit for a building with 'significant' demand could be up to £800,000. The net benefit for an installation that is considered to have high non-potable water demand is likely to be between these figures, nevertheless it shows that there is significant benefit to installing GWR in larger new developments.

Table 3-19: Net impact of installing GWR in high demand new developments (annual)

Number of new buildings per year	Impact	(millions)
332	£ 55,134,460	£ 55

3.2.4.1 P4.1: LPA requirement for installation of GWR in all new non-domestic buildings with high non-potable demand in specific high demand geographic region(s).

The policy P4 described above has been further refined to target non-domestic buildings in the water stressed regions on the East of England, the South East and London. This could reduce the daily water demand across this area for non-domestic buildings by 55 Ml per day by 2041 (Table 3-20).

Table 3-20: Modelled impact on non-domestic water demand from implementing policy option P4.1

		2021	2031	2041
Non-domestic water demand				
Business as usual	Ml/day	1,287	1,337	1,378
Policy scenario P4.1	Ml/day	1,287	1,309	1,323

Targeting the policy in water-stressed areas would reduce the number of new non-domestic buildings and developments to about 100 per year and also result in an annual benefit to the region of £10 million (Table 3-21). This is primarily through reduced water cost to businesses as well as carbon savings and reduced pressure of existing and future water infrastructure.

Overall however, targeting high demand in non-domestic buildings captures only a small number of new developments and therefore the overall impact, while a net benefit, is small.

Table 3-21: Net impact of installing GWR in high-potable water demand buildings split by geography

Number of new buildings per year	Impact	(millions)
116	£ 10,339,889	£ 10

3.2.5 P5: National requirement for retrofit of RWH in all public buildings.

One of the more ambitious policy options is to retrofit all public buildings in England and Wales with a RWH harvesting system. This would include schools, hospitals, libraries as well as other public administration and government buildings. The principle advantage of this is that, as publicly owned buildings less buy-in from third parties would be required and it could be directly funded by the government. The primary cost is that retrofitting is significantly more expensive than installing the system in a new build.

The other advantage or strength of the policy is that public buildings, particularly schools, tend to be larger buildings with a significant amount of roof space presenting attractive opportunities for RWH and significant water savings. It is assumed that it would take 20 years to retrofit all schools in England and Wales but that it could reduce non-domestic water consumptions by almost 500 Ml per day (Table 3-22).

Table 3-22: Modelled impact on non-domestic water demand from implementing policy option P5

		2021	2031	2041
Non-domestic water demand				
Business as usual	Ml/day	3,055	3,181	3,283
Policy scenario P5	Ml/day	3,055	2,997	2,915

Appendix 3 Section A3.3.6 provides a breakdown on how the number of public buildings in England and Wales is calculated (based on data provided by NOMIS). Table 3-23 (Appendix 3 Section A3.3.6 Table A3-12) shows the net impact and number of buildings that would need to be retrofitted. As mentioned, it is expected that the retrofit would occur over a number of years. Despite this the analysis below on the net impact shows the annual benefit if all public buildings were retrofitted.

This policy would require over 40,000 buildings to be retrofitted across England and Wales and that there would be an overall net benefit of £5.8 billion over 20 years, this includes the reduced water usage (which accounts for about half of all the benefit) and other indirect benefits included less CO_2 emitted and reduced stress on water infrastructure.

Table 3-23: Net impact of retrofitting RWH systems in all public buildings in England and Wales

Number of new buildings per year	Impact	Impact (millions)
42,371	£ 4,064,353,566	£ 4,064

3.2.5.1 P5.1: National requirement for retrofit of RWH in all public buildings over a certain size.

A potentially more feasible and cost effect approach could be just to require the retrofit of buildings that have a collection area over 2,000m^2. This would include just over 15,000 buildings in England and Wales and account for 36% of all public buildings. It would also result in a net benefit of almost £4.4 billion over 20 years, 75% of the net benefit realised if RWH systems were installed in all public buildings (Table 3-25; Appendix 3 Section A3.3.6 Table A3-13). If all the public buildings over 2,000m^2 were retrofitted, it could also reduce non-domestic water demand by over 200Ml per day by 2041 (Table 3-24).

Table 3-24: Non-domestic water demand from P5.1

		2021	2031	2041
Non-domestic water demand				
Business as usual	Ml/day	3,055	3,181	3,283
Policy scenario 5.1	Ml/day	3,055	3,074	3,069

Table 3-25: Net impact of retrofitting RWH systems in all public buildings with a collection area over 2,000m^2 in England and Wales

Number of new buildings per year	Impact	Impact (millions)
15,057	£ 2,722,963,092	£ 2,723

This policy shows that there is significant benefit to be achieved from installing RWH in lager buildings and avoids some of the less economically efficient options of installing systems in smaller buildings. Moreover, it ensures that all installations would have a private net benefit (the water savings outweigh the net costs) as well as a total public and private net benefit.

3.2.5.2 P5.2: National requirement for retrofit of RWH in all public buildings over a certain size in specific water stressed geographic region(s).

A final, more targeted approach would be to require the retrofitting of larger schools and other public buildings (with a potential collection area over 2,000m^2) in water stressed regions in the East of England, South East and London. This would have the benefit of reducing water demand by 140 Ml per day in the region (Table 3-26). It is assumes that this retrofitting would occur over a 20 year period, but the smaller number of buildings means that it could be installed in a shorter timeframe.

Table 3-26: Modelled impact on non-domestic water demand from implementing policy option P5.2

		2021	2031	2041
Non-domestic water demand				
Business as usual	Ml/day	1,287	1,337	1,379
Policy scenario 5.2	Ml/day	1,287	1,292	1,289

It would also bring significant wider benefits to the region, with an annual net benefit of over £1.7 billion, this includes reduced water costs for schools and other public buildings, carbon savings and particularly reduced costs from the requirement to build more water infrastructure to bring more water in to the water stressed areas (Table 3-27).

Table 3-27: Net impact of retrofitting all public buildings with a collection area over 2,000m^2 with RWH, split by geographic region

Number of new buildings per year	Impact	Impact (millions)
6,199	£ 1,294,213,449	£ 1,713

*The impact per installation for the total installation is calculated as the median of the different regions

3.2.6 P6: National requirement for the installation of a water reuse system in all new developments

A national requirement for installation a water reuse system in all new developments (new stock and the replacement of old stock) would be one of the most ambitious policies while allowing for flexibility over the type of system installed.

This policy would affect all new properties alike and it is assumed that either RWH or GWR would need to be installed to achieve this (but not both). The split between the percentage of total new builds that would install RWH and GWR harvesting has been modelled to reflect best estimates of the most likely installation in new builds. These estimates have been informed by the literature review, the perceived preference for RWH in current new builds and the underlying costs and benefits. Specifically, as GWR has a net cost for low and small demand properties, it is assumed that only a relatively small percentage of these buildings would install GWR. In larger buildings, the majority of new builds still install RWH, due to current trends, however GWR starts to become cost (and benefits) competitive and therefore a greater percentage will choose GWR. The modelled split across demands is shown in Table 3-28.

Table 3-28: Modelled percentage split between installing RWH and GWR in all new development

Demand	RWH	GWR
Low	95%	5%
Small	90%	10%
Medium	85%	15%
High	75%	25%
Significant	60%	40%

The key characteristic of the policy is that it would impact all new building development, domestic and non-domestic alike, therefore having the most wide reaching impact on water demand. Given the reach of the policy there are key caveats that may impact the effectiveness and the cost of the policy and its feasibility. The rate of water reuse installation in buildings is currently very low (when compared to total construction, the size of the water reuse market is therefore relatively small. If all new developments were required to install reuse systems this would place significant strain of the market place. In the short-term this could cause prices to rise, in the long term, prices are likely to fall due to the economy of scale. We would also likely see significant technological advancement in the sector as demand increases.

In the short term it is unlikely that there would be enough supply to meet the demand for all new developments to have water reuse installed. Table 3-29: Modelled impact on domestic and non-domestic water demand from implementing policy option P6**Error! Reference source not found.** shows the water demand under the baseline and policy scenario for domestic and non-domestic buildings. The analysis assumes sufficient capacity to install water re-use systems in all new developments after the policy is introduced.

Table 3-29: Modelled impact on domestic and non-domestic water demand from implementing policy option P6

		2021	2031	2041
Domestic water demand				
Business as usual	Ml/day	8,421	8,769	9,049
Policy scenario P6	Ml/day	8,421	8,358	8,228
Non-domestic water demand				
Business as usual	Ml/day	3,055	3,181	3,283
Policy scenario P6	Ml/day	3,055	2,960	2,840

The reduction in demand also brings significant financial savings both to the end user who sees reduced water bills and to water companies (though reduced investment in water infrastructure) and society (through reduced damages from floods and carbon savings). Estimates suggest that over 80,000 new developments a year would be impacted by this policy (this includes everything from new large domestic and non-domestic developments to individual house buildings), the vast majority of these developments would see RWH systems installed (approximately 90%) while a minority of, primarily larger buildings, would have GWH installed.

In total, over 80,000 buildings per year would require the installation of a water reuse system during development, this would potentially have a total net saving of over £1.5 billion of the lifetime of the re-use system (assumed to be 20 years). Similarly the split of impacts, sees approximately 90% of the net impact come from RWH installations. The total financial impact of installing a water reuse system in all new developments, taking in to account private and social impacts, are shown in Table 3-30.

Table 3-30: Total impact of installing RWH or GWR as part of a requirement for all new builds to have a water re-use system installed

	Number of new buildings per year	Impact	Impact (millions)
Rainwater harvesting systems	72,579	£ 1,370,246,482	£ 1,370
Grey water recycling systems	8,880	£ 163,001,720	£ 163
Total	81,459	£ 1,533,248,202	£ 1,533

3.2.7 P7: Behaviour change campaign to encourage uptake of RWH. Including the provision of technical guidance and case studies

Voluntary measures to incentive or encourage the uptake of RWH or GWR have also been modelled as part of a short list of policy options. This policy looks at a behaviour change campaign that would seek to encourage the uptake of rainwater and grey water harvesting. The campaign would include guidance, literature and case studies made available to developers highlighting the financial and wider benefits of installing these systems.

Given the greater payback (and particularly the private payback) of larger demand systems it is assumed that uptake would increase as the size (and demand) of the building increased. The uptake therefore ranges from 5% for smaller developments such as a single house, to 25% for the largest domestic and non-domestic developments. Furthermore, it is assumed that there would be no uptake of GWR for low and small demand developments given that there is a net cost of installing. The split between RWH and GWR for medium, high and significant demand buildings is consistent with the split set out in Table 3-31Table 3-31.

Table 3-31: Percentage of all new builds that would see new RWH or GWR installations as a result of the behavioural campaign

Demand	RWH	GWR
Low	5%	0%
Small	10%	0%
Medium	13%	2%
High	15%	5%
Significant	15%	10%

The analysis shows that overall, almost 4,500 new RWH or GWR installations could be installed every year. This could have a net benefit across the installation's lifetimes of over £300 million (Table 3-32). The majority of the benefit stems from rainwater harvesting, this is due both the higher percentage of installations in the split and the inclusion of low and small demand RWH systems that can still have a net benefit, unlike GWR.

Table 3-32: Net impact of a behavioural campaign to encourage more RWH and GWR in new developments.

	Number of new buildings per year	Net benefit (£)	Net benefit (£ millions)
RWH	4,334	£ 150,405,425	£ 150
GWR	113	£ 20,723,560	£ 21
Total	4,447	£ 171,128,984	£ 171

Despite the overall net benefit, the resulting impact on domestic and non-domestic demand is very low. The policy could save approximately 100Ml/day of domestic water consumption by 2041 and about 60 Ml/day of non-domestic demand, see Table 3-33. Given the compounding issues of climate change and population growth on water demand, a voluntary campaign alone would do very little to reduce the total amount of water required in England and Wales. However, this analysis does not include the use of subsidies or grants which could be jointly used to incentive uptake. Examples of these have been provided in Table 2-6 in Section 2.5.

Increasing the use or grants or subsidies would undoubtably increase the uptake of these schemes, particularly when combined with an additional voluntary measure and these approaches have been shown to be successful in other countries. The exact extent to which these subsidies or grants would drive uptake depends on the financial incentive and it is beyond the scope of this work to look at how various financial rewards would result in differing uptake.

Table 3-33: Modelled impact on non-domestic water demand from implementing policy option P7

		2021	2031	2041
Domestic water demand				
Business as usual	Ml/day	8,421	8,769	9,049
Policy scenario P7	Ml/day	8,421	8,712	8,936
Non-domestic water demand				
Business as usual	Ml/day	3,055	3,181	3,283
Policy scenario P7	Ml/day	3,055	3,148	3,216

3.2.8 P8: Extend existing schemes (e.g. BREEAM, BRE Home Quality Mark) to include the installation of RWH or GWR.

A further potential voluntary policy option accessed would be to include the installation of RWH and GWR in the current voluntary schemes that incentivise good building practices such as BREEAM and the BRE Home Quality Mark.

Analysis of a voluntary scheme therefore assumes that some percentage of all new developments would include RWH or GWR as part of these development schemes. Between 2013 and 2017 approximately 9,000 BREEAM certificates were issued to projects in the UK, 1,800 projects annually. Based on this an estimate of the impact if half of these BREEAM certified projects installed RWH or GWR has been derived[40]

Moreover, analysis of the type of projects that seek BREEAM certification suggests they will typically be larger multi-dwelling domestic or non-domestic developments. Therefore the analysis has been limited to sites with a collection area over 5,000m^2 and demand over 2,500 m^3 for RWH and demand over 1,500 m^3 for GWR, this roughly equates to 900 new developments annually (including both domestic and non-domestic).

In the analysis, the split between RWH and GWR was kept consistent with assumptions set out in Table 3-34. This would see approximately 700 new installations of RWH and 200 in GWR systems annually. The net impact, over the 20 year lifetime of the system is set out in Table 3-35.

Table 3-34: Estimated benefit of installing RWH or GWR in BREEAM certified buildings

Installation type	Number of new buildings per year	Total net benefit (£)	Net benefit (£ million)
Rainwater harvesting	755	£ 194,659,775	£ 195
Grey water recycling	145	£ 39,836,820	£ 40
Total	900	£ 234,496,595	£ 234

The numbers represent the annual number of installations that would be installed, the costs and benefits are estimated over the systems 20 year lifetime.

Finally, the inclusion of RWH and GWR in BREEAM could result in a significant water demand reduction for domestic and non-domestic buildings. Encouraging the systems in large new developments could see domestic demand fall by 300 Ml/day by 2041 and non-domestic demand fall by approximately 50Ml/day (Table 3-35).

Table 3-35: Modelled impact on non-domestic water demand from implementing policy option P8

		2021	2031	2041
Domestic water demand				
Business as usual	Ml/day	8,421	8,749	9,049
Policy scenario P8	Ml/day	8,421	8,620	8,751
Non-domestic water demand				
Business as usual	Ml/day	3,055	3,181	3,283
Policy scenario P8	Ml/day	3,055	3,151	3,223

3.2.9 Reducing future costs through requiring dual pipe systems in buildings.

An additional option not modelled here would be to require all new developments to install a dual pipe system that would allow for a significantly reduced cost of retrofitting RWH or GWR systems in the future. Research on current RWH and GWR retrofit shows that these require a significant amount of plumbing to achieve and can be very disruptive. Initial research suggests that new buildings could be designed to include a dual pipe system at the outset for very little additional cost, significantly reducing the cost of installing a RWH or GWR system in the future. Insufficient information is available to estimate the costs and benefits of this type of requirement and to provide any further analysis.

3.3 Accessing the zero-carbon agenda

This section considers at the specific carbon savings that can be made within an agenda to increase to use of water reuse equipment. The policy overview in Section 3.2 includes the carbon emissions from these systems expressed as a carbon price within the net impacts. For an understanding of how these carbon savings fit in to the net impact refer to the Waterwise (2020) report: Independent review of the costs and benefits of rainwater harvesting and grey water recycling options in the UK. This section goes beyond calculating the carbon price of each system to specifically discussing how RWH and GWH can form part of the water industry's zero carbon agenda.

Analysis by the Environment Agency found that the carbon footprint of the current water system is approximately 7 tCO_2e/Ml, this has produced an average incremental carbon cost (AICC) of £0.28 /m^3 of mains water[41]. This figure has been used to estimate the benefit from reducing a buildings mains water use through the installation of a RWH or GWR system.

Information on the carbon embedded in a RWH system and the expected CO_2 emitted from the ongoing maintenance of a system (including the replacing of parts and the emissions of an engineer driving to a site) were provided by RWH suppliers. This has allowed an estimate of the total amount of CO_2 emitted over the entire lifetime of a RWH system and the associated costs to be derived.

For GWR systems a similar process was carried out, however no data was provided on the CO_2 emissions by suppliers. Instead, examples of carbon in other GWR systems recorded in an Environment Agency report were used (Environment Agency, 2011). The examples provided in the report were matched to the yield categories based on the building type, data on the lifetime CO_2 of a system and a 2020 carbon price were used to estimate the cost associated with the system.

These calculations (shown in Table 3-36 and Table 3-37) allow an estimate of the cost of the carbon associated with installing a RWH or GWR system to be established against the amount of carbon saved (in terms of the societal cost) through reducing the use of mains water.

Both RWH and GWR systems save significantly more CO_2, through the reduction of mains water, than the systems emit. The carbon impacts of both systems and the carbon in the water is presented as a cost associated with that carbon (known as a carbon price), carbon price calculations are made using BEIS supplementary Green Book Guidance[42].

The installation data underpinning this analysis is primarily made up of larger buildings and systems where significant amounts of mains water can be saved. In these instances greater savings in CO_2 compared to the CO_2 emitted through the mains water system can be achieved. The observed tendency for larger buildings to install water reuse systems over recent years suggest that the systems could help decarbonise the water system, however significantly less certainty (due to a lack of data) is given to the role that smaller water reuse systems could play in helping to decarbonise the water industry.

[41] EA (2008) Greenhouse gas emissions of water supply and demand management options. It is likely that the carbon intensity of the water system has reduced since this report was published however this is unknown. The figures in the report are therefore used although they may over-estimate the carbon saving.
[42]https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/602657/5._Data_tables_1-19_supporting_the_toolkit_and_the_guidance_2016.xlsx

3.3.1.1 Reducing CO_2 emissions through increased rainwater harvesting

This analysis shows that installing RWH systems can support the aim of reducing CO_2 emissions in the water industry and achieving net zero carbon emissions. For all types and sizes of system the emissions from a RWH system are significantly lower than the emissions from the mains water infrastructure. The total carbon cost of a RWH system is between £600 and £10,000 over the systems 20 year lifetime. The carbon cost of the mains water that is avoided through the use of RWH is between £900 and £275,000 (Table 3-37).

Table 3-36 provides an indicative range of the carbon savings that can be made by installing a RWH system in buildings of different sizes, the exact amount depends on the capacity of the RWH tank and the total amount of water offset.

Table 3-36: Range of potential carbon savings (annually) from installing a RWH system (tonnes of CO_2)

Collection area	Example building types	Tonnes of CO_2 from the installation and maintenance of RWH	Tonnes of CO_2 from offset water
Small (<500m^2)	Standalone dwellings, houses, bungalows.	8-16	11-181
Medium (500 – 2000m^2)	Some larger houses or two semi-detached houses.	10-19	31-701
Large (2000 – 5000m^2)	Row of terraced houses or blocks of flats.	11-20	24-537
Very Large (>5,000m^2)	Large scale residential developments (including hybrid developments).	10-141	24-3,350

The range includes systems for all buildings types. The carbon saving from mains water for a smaller dwellings (small or medium collection area with low demand) is between £900 and £2,600, compared to the carbon in a RWH system for building that size, which is between £600 and £1,300. While these figures are represented as costs, to allow for an accurate comparison, they are not costs that would be borne by either to household or the supplier, the costs reported here represent the social cost of carbon when it is emitted.

When these results are considered in relation to the policies discussed in Section 3.2 **Error! Reference ource not found.**it can be noted that all system sizes reduce the amount of CO_2 emitted but that focussing on larger systems, systems with large collections areas and demands, such as hotels, blocks of flats, large office developments and community developments could significantly reduce the amount of CO_2 emitted. The amount of CO_2 embedded within a RWH system does not grow significantly as the size increases, however the amount of CO_2 saved, through reduced water demand can increase significantly with the size and demand of the systems. This would suggest focusing on larger installations and new developments to maximise the reduction in CO_2 emissions in the water system.

Overall this shows that RWH could have a role to play in decarbonising the water system. Rain water systems, particularly larger systems emit less CO_2 than is emitted in the process and transportation of mains water and therefore could support further decarbonisation of the water supply in England and Wales.

Table 3-37: Carbon cost of installing a RWH system compared to receiving the water from the mains system over 20 year lifetime

Collection area	Demand	CO_2 embedded in the system (kg)	CO_2 emissions from system Opex (kg)	Total carbon cost of RWH system (£)	Annual carbon saving (£)[43]	Total cost of carbon reduction from mains water (£)
Small	Low	7,637	37	**£ 590**	£38	**£ 912**
Small	Small	8,499	64	**£ 690**	£357	**£ 8,398**
Small	Medium	14,954	63	**£ 1,143**	£638	**£ 14,997**
Small	High	-	-	-	-	-
Small	Significant	-	-	-	-	-
Medium	Low	18,653	30	**£ 1,357**	£109	**£ 2,584**
Medium	Small	8,597	67	**£ 701**	£368	**£ 8,666**
Medium	Medium	12,837	116	**£ 1,070**	£742	**£ 17,447**
Medium	High	10,780	240	**£ 1,102**	£1,646	**£ 38,694**
Medium	Significant	7,211	397	**£ 1,075**	£2,469	**£ 58,022**
Large	Low	10,750	27	**£ 795**	£86	**£ 2,021**
Large	Small	11,622	80	**£ 933**	£455	**£ 10,706**
Large	Medium	13,191	156	**£ 1,151**	£964	**£ 22,661**
Large	High	11,539	239	**£ 1,154**	£1,642	**£ 38,596**

[43] Annual carbon savings from reduced water use are calculated by multiplying the average water saving for a system of that size by the carbon price of the carbon in mains water

Collection area	Demand	CO_2 embedded in the system (kg)	CO_2 emissions from system Opex (kg)	Total carbon cost of RWH system (£)	Annual carbon saving (£)[43]	Total cost of carbon reduction from mains water (£)
Large	Significant	11,138	462	**£ 1,444**	£1,889	**£ 44,395**
Very Large	Low	9,732	27	**£ 724**	£86	**£ 2,026**
Very Large	Small	-	-	-	-	-
Very Large	Medium	28,021	176	**£ 2,225**	£1,181	**£ 27,752**
Very Large	High	26,829	225	**£ 2,210**	£1,428	**£ 33,563**
Very Large	Significant	78,934	3,109	**£ 9,994**	£11,798	**£ 277,203**

3.3.1.2 Reducing CO_2 emissions through increased grey water recycling

With grey water recycling, the analysis shows that this can also support the aim of reducing CO_2 emissions in the water industry. All sizes of GWR systems result in a net reduction of GHG emissions, however the net CO_2 reduction is larger as the system size increases and more mains water is offset. The total carbon cost associated with installing a GWR system ranged between £100 for the smallest system (such as that seen in a single house) up to £3,650 for the largest system (such as a community system to a very large block of flats). The carbon savings from emissions that would have been emitted through mains water use ranges between £700 for individual houses and £113,000 for the largest installations (Table 3-38)[44].

Again, while these figures are represented as costs in order to allow for an accurate comparison, they are not costs that would be borne by either to household or the supplier, the costs reported here represent the social cost of carbon when it is emitted.

When these results are considered in relation to the policies discussed in Section 3.2 it is noted that all system sizes reduce the amount of CO_2 emitted but that focussing on larger systems, systems with a larger yield, such as hotels, blocks of flats, large office developments and community developments could significant reduce the amount of CO_2 emitted. The amount of CO_2 embedded within a GWR system does not grow significantly as the size increases, however the amount of CO_2 saved, through reduced water demand can increase significantly with the size and yield of the systems. This would suggest focusing on larger installations and new developments to maximise the reduction in CO_2 emissions in the water system.

Overall this highlights that GWR could also have a role to play in decarbonising the water system. Grey water systems, particularly larger systems emit less CO_2 than is emitted in the process and transportation of mains water and would therefore support further decarbonisation of the water industry.

Table 3-38: Carbon cost of installing a GRW system compared to receiving the water from the mains system over 20 year lifetime

Yield	CO_2 in GWR system (lifetime)	Carbon cost of GWR system	Annual carbon saving (£)	Total carbon saving (£)
Low	**1,254**	**£ 88**	30	**£ 712**
Small	**9,097**	**£ 641**	324	**£ 7,601**
Medium	**19,535**	**£ 1,376**	713	**£ 16,760**
High	**29,973**	**£ 2,111**	1,093	**£ 25,677**
Significant	**52,057**	**£ 3,667**	4,830	**£ 113,479**

[44] It was not possible to express carbon savings for GWH in terms of kg CO_2 due to limitations in the data received from suppliers.

4 Conclusions and recommendations

The short-listed policies presented in this document represent a wide range of options to encourage the uptake of RWH and GWR systems as a method for reducing household and non-domestic water demand and as a potential way of decarbonising the water system in England and Wales.

In conclusion the analysis conducted on the shortlisted policy options presents a clear narrative on how RWH and GWR can be incentivised or required through regulation in order to reduce the demand on current water infrastructure. This is represented by the reduced PCC and non-domestic water demand set out for each policy in Table 3-3 and Table 3-4.

Policies that focus on larger buildings, particularly large scale dwellings (residential development) or high rise flats and large office buildings have been shown to provide a significant net benefit, both privately for the owner, and for the wider public.

The analysis has also shown that all size of RWH and GWR system reduce the amount of GHG emissions from the water industry. While there are CO_2 emissions associated with the installation and maintenance of these systems, they are significantly less than the CO_2 embedded in the current mains water system.

The analysis has also explored through key examples, that while all RWH and GWR systems will reduce water demand, the impact on PCC can vary significantly depending on the type of, and size of the building, and the number of inhabitants or building occupancy. Overall however it has shown that the widespread uptake of RWH and GWR does reduce demand and could partially alleviate pressure on water resources, given that in some cases, the policy would reduce demand by a greater amount than demand is forecasted to grow. In addition, the policies explored in this section would also potentially reduce the damage from floods, reduce the amount of CO_2 in the water system and, for all but the smallest systems, provide a financial net benefit for the system owner over its lifetime.

A full impact assessment of each policy option is required to establish the best policy option(s) to achieve water demand and carbon reductions, however some key insights and conclusions have been drawn out of this work.

- Overall, all the policies shortlisted would reduce domestic and non-domestic water demand over the next 20 years if implemented. The policies with the most significant potential water savings are highlighted below:

Policy	Domestic (Ml/d)	Non-domestic (Ml/d)	Total net benefit (£billion)
	2041	**2041**	**2041**
Business As Usual (BAU) – modelled total demand	9,049	3,283	-
P1: National requirement for new developments to be built to <80 l/p/day[45]	821	-	£1.1
P2: National requirement for installation of RWH in all new developments.	822	447	£1.6
P5: National requirement for retrofit of RWH in all public buildings	-	368	£1.7
P6: National requirement for the installation of a water reuse system in all new developments.	821	443	£1.5

[45] This policy assumes that all new buildings will need to be built 80l/p/day, however this is not achievable by installation reuse systems alone. The PCC numbers represent a national average of all buildings.

- Both RWH and GWR systems emit less CO_2 over their lifetime than mains water and would therefore help to decarbonise the water industry:
    - The carbon cost of the mains water that is avoided through the use of RWH is between £900 and £275,000 over the systems 20 year life time.
    - Carbon cost of installing a GWR system compared to receiving the water from the mains system over 20 year lifetime ranges between £700 for individual houses and £113,000 for the largest installations.

    Note: Key steps would have to be taken to reduce emissions from reuse systems (such as vehicle emissions from ongoing maintenance) and the plastic used makes it difficult to fully decarbonise without further R&D.

    - Policies that impact the largest number of buildings have the biggest impact on reducing overall water demand.
- Linking rainwater harvesting to SUDs is a very attractive policy option as it significantly reduces the upfront costs and focuses deployment of the technology on the larger sites where they can achieve the most benefit, both through reducing water demand and providing flood damage reduction.
- Policies that specifically target water the stressed areas of London, the East and South East of England can help reduce demand in regions where PCC is already higher than the national average.
- Policies that target larger buildings reduce PCC but are less effective at reducing overall PCC reductions. However, installing reuse systems in larger systems is more cost effective and results in a greater net benefit.
- Installations were water demand is low, such as individual households, small retail premises and office spaces result in a net cost, where uptake is voluntary, thus only uptake in larger buildings is likely.
- All quantitative analysis of the potential benefits, both of reduced water demand and societal savings are predicated on sufficient rainfall for RWH to occur. The analysis is based of real world data and therefore assumed to reflect rainfall. Two key caveats are:
    - Analysis takes the average of all data received and therefore may differ in water stressed areas
    - As climate change continues and rain patterns change, the amount of rainfall may diminish.

In order to make further recommendations on the effectiveness of each policy a full impact assessment would be required alongside a greater understanding of how PCC reductions would interact with other plans by water companies to reduce water demand.

5 References

Acteon. Economic instruments for mobilising financial resources for supporting IWRM, 2010

Artesia Consulting. The long term potential for deep reductions in household water demand, 2018.

Australian Government. National Rainwater and Grey water Initiative: Household Rebate Guidelines, 2009.

Campisano, Butler, Ward, Burns, Friedler, DeBusk, Fisher-Jeffes, Ghisi, Rahman, Furumai and Han. Urban rainwater harvesting systems: research, implementation and future perspectives. Water Research, 115, 2017.

Chubaka, Whiley, Edwards, and. Ross. A Review of Roof Harvested Rainwater in Australia. Journal of Environmental and Public Health, 2018.

Defra. Sustainable Drainage Systems Non-statutory technical standards for sustainable drainage systems, 2015.

DCLG, Code for Sustainable Homes Technical Guide 2010.

Environment Agency, Energy and carbon implications of rainwater harvesting and grey water recycling, 2011.

Godskesen, Hauschild, Rygaard, Zambrano and Albrechtsen. Life-cycle and Freshwater Withdrawal Impact Assessment of Water Supply Technologies. Water Research, 47, issue 7, 2013.

HM Government, The Building Regulations 2010 – Drainage and waste disposal - 2015 edition: Approved Document H, 2015.

HM Government, The Building Regulations 2010 - Sanitation, hot water safety and water efficiency - 2015 edition with 2016 amendments: Approved Document G, 2016.

Japan for Sustainability. Let's Use Rainwater! Recent Trends in Rainwater Use in Japan.2014 https://www.japanfs.org/en/news/archives/news_id035023.html

Japan for Sustainability. Cabinet of Japan Decide to Make Full Use of Rainwater in Newly Constructed Buildings, 2015 https://www.japanfs.org/en/news/archives/news_id035257.html

Juan, Chen and Lin. Grey water Reuse System Design and Economic Analysis for Residential Buildings in Taiwan. Water, 8, 2016

Ministry of Housing, Communities and Local Government. National Planning Policy Framework, 2019

National Infrastructure Commission, Preparing for a drier future: England's water infrastructure needs, 2018.

Nolde. Grey water recycling systems in Germany - results, experiences and guidelines. Water, Science and Technology, 51, Vol 10, 2005

NYC Environmental Protection. 2019/20 New York City Water Conservation and Reuse Grant Pilot Program Guide, 2019

OECD, Environmental Performance Reviews: Germany 2012

Schuetze. Rainwater harvesting and management – policy and regulations in Germany. Water, Science and technology: water supply, 13.2, 2013

Struk-Sokołowska, Gwo´zdziej-Mazur, Jadwiszczak, Butarewicz, Ofman, Dowikowski and Ka´zmierczak. The Quality of Stored Rainwater for washing purposes. Water, 12, 2020

Thames Water. Non-Potable Water Reuse as a Demand Management Option for WRMP19 Options Appraisal Report, 2017

The College of Estate Management, Grey water for UK housing, 2013

Tucson Water. Graywater Information Guide, 2011

US Department of Energy. Rainwater Harvesting State Regulations and Technical Resources, 2015

Water UK, Water resources long term planning framework (2015-2065), 2016

Waterwise, How Do People Feel About Domestic Water Recycling Systems? 2019.

Waterwise, Independent review of the costs and benefits of rainwater harvesting and grey water recycling options in the UK, 2020.

Welsh Government, Sustainable Drainage (SUDS) Statutory Guidance, 2019

Yannopoulos, Giannopoulou and Kaiafa-Saropoulou. Investigation of the Current Situation and Prospects for the Development of Rainwater Harvesting as a tool to Confront Water Scarcity Worldwide. Water, 11, 2019

Yu, Rahardianto, DeShazo, Stenstrom, Cohen. Critical Review: Regulatory Incentives and Impediments for Onsite Graywater Reuse in the United States. Water Environment Research, 85, No 7, 2013.

Appendices

A1 Appendix 1: Summary of results from cost benefit analysis of RWH and GWR systems in the UK

Table A1-1 Range of costs and benefits for installing RWH based on the collection area of a domestic building (Waterwise, 2020)

Collection area	Example building types	Costs: CAPEX + OPEX ('000 £)	Water cost savings ('000 £)	Private net benefits ('000 £)	Societal benefits ('000 £)	Total net benefit ('000 £)
Small (<500m^2)	Standalone dwellings, Houses, Bungalows;	£12 - £19	£1 - £19	-£9 - £26	£21 - £77	**£10 - £100**
Medium (500 – 2000m^2)	Some larger houses or two semi detached houses;	£25 - £38	£8 - £200	-£17 - £150	£50 - £163	**£35 - £340**
Large (2000 – 5000m^2)	Row of terraced houses or blocks of flats;	£20 - £35	£7 - £150	-£15 - £120	£35 - £335	**£20 - £450**
Very Large (>5,000m^2)	Large scale residential developments (including hybrid developments)	£35 - £60	£70 - £340	-£17 – £280	£30 - £920	**£14 – £1,200**

Notes: Building types are based on provided examples and an exact costing will depend on the size and scale of the project and different building types may fall in different collection area sizes; Water cost savings are the savings made from reduced mains water demand; Private net benefits look at the water savings vs total cost. Total net benefits also include CO_2 savings, infrastructure costs and flood alleviation.

Table A1-2 Range of costs and benefits for installing RWH based on the collection area of a non-domestic building (Waterwise, 2020)

Collection area	Example building types	Costs: CAPEX + OPEX ('000 £)	Water cost savings ('000 £)	Private net benefits ('000 £)	Societal benefits ('000 £)	Total net benefit ('000 £)
Small (<500m^2)	Small commercial shops (such as a corner shop);	£12 - £19	£1 - £19	-£11 - £28	£8 - £51	**-£3 - £80**
Medium (500 – 2000m^2)	Retail and commercial stores, Leisure centres;	£25 - £38	£8 - £200	-£17 - £160	£23 - £150	**£6 - £315**
Large (2000 – 5000m^2)	Office blocks, hotels and shopping centres;	£20 - £35	£7 - £140	-£15 - £110	£16 - £190	**£1 - £300**
Very Large (>5,000m^2)	Large scale commercial developments (including hybrid developments)	£25 - £60	£7 - £315	-£17 – £260	£15 - £500	**-£3 – £742**

Notes: Building types are based on provided examples and an exact costing will depend on the size and scale of the project and different building types may fall in different collection area sizes; Water cost savings are the savings made from reduced mains water demand; Private net benefits look at the water savings vs total cost. Total net benefits also include CO_2 savings, infrastructure costs and flood alleviation.

Table A1-3 Costs and benefits of installing a GWR system in a building based on the systems yield (greywater produced; Waterwise,2020)

Yield	Example building types	Costs (CAPEX + OPEX; '000 £)	Total water cost savings ('000 £)	Private net benefits ('000 £)	Societal benefits ('000 £)	Total net benefit ('000 £)
Low (<500m^3)	Smaller households (such as retired people or young adults), small commercial shops.	£ 45	£ 5	-£ 40	2	**-£ 37**
Small (500 – 1,500m^3)	Larger households (potentially families).	£ 100	£ 52	-£ 48	£18	**-£ 30**
Medium (1,500 – 4,000m^3)	Retail and commercial stores, leisure centres, some offices.	£ 120	£ 108	-£ 13	£34	**£ 25**
Large (4,000 – 10,000m^3)	Large commercial settings such as shopping centres, multi-unit offices or flats.	£ 170	£ 190	£ 21	£67	**£ 88**
Significant (>10,000m^3)	High rise offices or blocks of flat, hotels, multi-purpose developments.	£ 270	£ 780	£ 510	£275	**£ 787**

Notes: Building types are based on provided examples and an exact costing will depend on the size and scale of the project and different building types may fall in different collection area sizes; Building types/groupings are the same for commercial and residential GWH installations; Water cost savings are the savings made from reduced mains water demand; Private net benefits look at the water and sewage savings vs total cost. Total net benefits also include CO_2 savings and infrastructure costs.

A2 Appendix 2: Results from multi-criteria analysis of policy options

a) Domestic Planning and Regulation

Ref	Policy option	Effectiveness in driving take up	Speed of take up	Ability to drive uptake across all building types	Efficiency of take up	Acceptability	Feasibility/ deliverability	Potential scale of impact	Score
D1	LPA requirement for new developments to be built to <100 l/p/day	1	2	2	0	1	-1	2	**7**
D2	National requirement for new developments to be built to <80 l/p/day	3	1	3	2	0	-2	3	**10**
D3	National requirement for installation of RWH in all new developments	3	1	3	2	1	-1	2	**11**
D4	LPA requirement for installation of combined (RWH/GWR) in all new developments in specific geographic region(s)	3	2	2	3	-2	-2	1	**7**
D5	LPA requirement for installation of RWH in all new developments in specific geographic region(s)	3	2	2	2	2	-1	2	**12**
D6	National requirement for all new developments to reuse a proportion of its water consumption.	3	1	3	3	-1	-1	2	**10**
D7	LPA requirement for SUDs /stormwater attenuation schemes to be designed with RWH in new developments.	3	2	3	2	2	-1	2	**13**
D8	LPA requirement for a proportion of the SUDs capacity to be used to reduce overall development water demand.	3	2	3	2	2	-1	2	**13**
D9	National requirement for retrofit of RWH in domestic buildings	2	-1	1	2	-3	-3	1	**-1**
D10	National requirement for retrofit of RWH in domestic buildings in specific geographic region(s)	2	-1	1	2	-2	-2	1	**0**
D11	National requirement for the installation of a water reuse system in all new developments	3	1	3	2	1	-1	2	**11**
D12	National requirement for installation of GWR in all new developments	3	1	2	2	-2	-2	1	**5**

b) Non-domestic Planning and Regulation

Ref	Policy option	Effectiveness in driving take up	Speed of take up	Ability to drive uptake across all building types	Efficiency of take up	Acceptability	Feasibility/ deliverability	Potential scale of impact	Score
C1	National requirement for installation of RWH in all new developments	3	1	3	2	1	-2	2	**10**
C2	LPA requirement for installation of RWH in all new developments over a certain size.	3	1	2	2	1	-2	2	**9**
C3	LPA requirement for installation of RWH in all new developments over a certain size in specific geographic region(s)	3	2	1	2	2	-1	1	**10**
C4	National requirement for all new developments to reuse a proportion of its water consumption.	3	1	3	3	2	-1	2	**13**
C5	LPA requirement for SUDs /stormwater attenuation schemes to be designed with RWH in new developments.	3	2	3	2	2	-1	2	**13**
C6	LPA requirement for a proportion of the SUDs capacity to be used to reduce overall development water demand.	3	2	3	2	2	-1	2	**13**
C7	National requirement for installation of GWR in all new non-domestic residential buildings.	3	1	1	2	-1	-1	2	**7**
C8	LPA requirement for installation of GWR in all new non-domestic buildings with high non-potable water demand.	3	2	2	2	0	-1	2	**10**
C9	LPA requirement for installation of GWR in non-domestic buildings with high non-potable demand in specific geographic region(s).	3	2	1	2	0	-1	1	**8**
C10	National requirement for retrofit of GWR in existing non-domestic residential buildings in specific geographic region(s).	1	-1	1	1	-1	-2	1	**0**
C11	National requirement for retrofit of GWR in existing non-domestic buildings with high non-potable demand.	1	-1	2	1	0	-1	2	**4**
C12	National requirement for the installation of a water reuse system in all new developments	3	1	3	2	1	-1	2	**11**

c) Government Estate

Ref	Policy option	Effectiveness in driving take up	Speed of take up	Ability to drive uptake across all building types	Efficiency of take up	Acceptability	Feasibility/ deliverability	Potential scale of impact	Score
G1	National requirement for retrofit of RWH in all public buildings.	3	2	2	2	1	-2	2	**10**
G2	National requirement for retrofit of RWH in all public buildings over a certain size.	3	2	2	2	2	-1	2	**12**
G3	National requirement for retrofit of RWH in all public buildings over a certain size in specific geographic region(s).	3	2	3	1	3	-1	2	**13**
G4	National requirement for retrofit of GWR in existing buildings with high non-potable demand.	1	2	2	1	1	-1	2	**8**
G5	National requirement for retrofit of GWR in existing buildings with high non-potable demand in specific geographic region(s).	1	2	2	1	2	-1	2	**9**
G6	National requirement for the installation of a water reuse system in all new public buildings	3	2	3	2	1	-2	2	**11**

A3 Appendix 3: Data and assumptions made in the policy analysis.

A3.1 Residential dwellings and business units in England and Wales

Table A3-1: Number of residential dwellings, by region, in England and Wales

Dwelling Type	East	East Midlands	London	North East	North West	South East	South West	Wales	West Midlands	Yorkshire and The Humber	Total
Detached house	744,954	634,599	211,232	184,614	558,252	1,037,388	716,955	383,737	563,249	477,309	**5,512,289**
Semi-detached house	769,846	692,791	629,607	456,002	1,123,976	1,022,394	656,137	429,955	876,381	849,261	**7,506,350**
Terraced (including end-terrace) house	577,263	406,998	776,821	358,783	944,608	829,923	559,150	385,379	545,544	643,879	**6,028,348**
Purpose-built block of flats or tenement	348,277	183,026	1,274,526	141,829	408,197	598,222	308,081	133,517	317,169	275,124	**3,987,968**
Part of a converted or shared house	53,284	31,627	429,456	27,649	76,216	149,158	120,358	33,051	44,945	51,591	**1,017,335**
Flat, maisonette or apartment, in a non-domestic building	22,473	17,113	62,795	9,044	30,427	41,190	28,819	14,097	23,614	21,743	**271,315**

Table A3-2: Total number of businesses units, by industry and geography (2019)

Industry	East	East Midlands	London	North East	North West	South East	South West	Wales	West Midlands	Yorkshire and The Humber	Total
Agriculture, forestry & fishing	12,480	11,530	780	4,130	11,960	12,355	25,010	13,995	12,985	12,095	153,725
Mining, quarrying & utilities	1,835	1,365	2,860	680	1,930	2,470	1,920	1,040	1,550	1,595	20,460
Manufacturing	15,240	13,185	14,840	4,985	16,140	20,005	13,465	6,420	15,660	13,405	148,550
Construction	43,280	23,710	57,295	9,470	32,165	57,905	32,820	14,000	26,245	24,270	353,620
Motor trades	9,895	7,660	7,395	2,845	9,390	12,880	8,705	4,220	8,795	7,720	87,995
Wholesale	12,535	9,055	21,735	2,945	13,280	17,750	9,405	4,120	11,740	9,455	122,945
Retail	27,435	19,925	50,845	9,800	36,565	43,155	25,355	13,695	24,695	23,670	306,645
Transport & storage	15,375	12,460	15,595	3,045	15,135	15,355	8,860	5,595	14,700	11,740	128,240
Accommodation & food services	17,210	12,920	33,070	7,885	21,465	26,740	19,750	10,355	15,795	16,475	204,265
Information & communication	23,420	10,580	73,845	3,640	16,660	47,190	17,065	4,950	13,350	10,575	234,925
Financial & insurance	6,520	5,895	17,965	1,775	9,250	10,760	6,010	2,630	4,980	4,890	77,215
Property	10,530	7,060	27,585	2,720	11,045	16,210	9,805	3,395	8,625	7,635	114,285
Professional, scientific & technical	46,990	26,950	124,145	12,110	45,715	84,870	37,825	13,085	32,995	27,990	492,940
Business administration & support services	26,580	15,825	58,530	7,280	27,295	43,230	20,560	9,850	22,960	16,585	268,870
Public administration & defence	2,545	2,005	1,920	920	2,140	2,825	2,420	1,645	1,835	2,085	24,185
Education	7,245	5,285	11,275	2,420	7,655	11,190	6,285	3,275	6,070	5,495	74,755
Health	14,205	11,025	24,125	5,895	17,800	22,620	14,100	8,115	13,285	12,755	160,990
Arts, entertainment, recreation & other services	18,535	14,045	40,375	6,480	19,925	30,130	16,810	8,360	14,825	14,125	205,960
Total	**311,855**	**210,490**	**584,185**	**89,020**	**315,525**	**477,645**	**276,170**	**128,745**	**251,085**	**222,575**	3,180,610

A3.2 Relationship between building types and analysis categories

Table A3-3 Estimated relationship between collection area and building type (percentage)

Collection Area	Small	Medium	Large	Very Large
Domestic buildings				
House type				
Detached	0.9	0.08	0.2	0
Semi-detached	0.95	0.05	0	0
Terraced	1	0	0	0
Purpose built block (up to approx. 15 stories)	**0**	0.25	0.5	0.25
Non-domestic building conversion	0	0	0.5	0.5
Developments				1
Non-domestic buildings				
Business type				
Micro	1	0	0	0
Small	0	1	0	0
Medium	0	0	1	0
Large	0	0	0	1

Table A3-4: Estimated relationship between demand and building type (percentage)

Demand	1: Low	2: Small	3: Medium	4: High	5: Significant
Domestic buildings					
House type					
Detached	0.95	0.05	0	0	0
Semi-detached	1	0	0	0	0
Terraced	1	0	0	0	0
Purpose built block (up to approx. 15 stories)		0.2	0.5	0.3	0
Non-domestic building conversion	0	0.5	0.5	0	0
Developments	**0**	0	0.5	0.3	0.2
Non-domestic buildings					
Business type					
Small	0.25	0.5	0.25	0	0
Medium	0	0.25	0.5	0.25	0
Large	**0**	0	0.5	0.5	0
Very Large	**0**	0	0.25	0.25	0.5

A3.3 Detailed breakdown of impacts for each policy option

A3.3.1 P1: Results tables

Table A3-5 Net impact of installing RWH in new builds to achieve 80 l/p/day

Collection Area	Demand	Number of buildings affected	Impact	(millions)
Small	Low	62,472	£ 625,708,498	£ 626
Small	Small	816	£ 39,366,814	£ 39
Small	Medium	-	£ -	£ -
Small	High	-	£ -	£ -
Small	Significant	-	£ -	£ -
Medium	Low	2,768	£ 101,481,480	£ 101
Medium	Small	121	£ 5,730,704	£ 6
Medium	Medium	116	£ 11,066,202	£ 11
Medium	High	61	£ 12,701,856	£ 13
Medium	Significant	-	£ -	£ -
Large	Low	364	£ 7,833,762	£ 8
Large	Small	165	£ 11,583,674	£ 12
Large	Medium	277	£ 37,673,836	£ 38
Large	High	122	£ 24,215,979	£ 24
Large	Significant	-	£ -	£ -
Very Large	Low	-	£ -	£ -
Very Large	Small	98	£ -	£ -
Very Large	Medium	502	£ 105,273,434	£ 105
Very Large	High	241	£ 58,720,084	£ 59
Very Large	Significant	96	£ 115,364,566	£ 115
Total		**68,219**	**£ 1,156,720,888**	**£ 1,157**

Table A3-6 Net impact of installing GWR in new builds to achieve 80 l/p/day

Demand	Number of buildings affected	Impact	Impact (millions)
Low	3453	-£ 128,774,529	-£ 129
Small	133	-£ 3,836,948	-£ 4
Medium	158	£ 4,000,679	£ 4
High	142	£ 12,426,057	£ 12
Significant	64	£ 50,399,168	£ 50
Total	3,950	**-£ 65,785,574**	-£ 66

A3.3.2 P2: Results tables

Table A3-7: Net impact of installing a RWH system in every new development

Collection Area	Demand	Number of buildings	Impact	Impact (millions)
Small	Low	66,774	£ 655,639,022	£ 656
Small	Small	2,935	£ 110,262,460	£ 110
Small	Medium	1,014	£ 79,929,942	£ 80
Small	High	-	£ -	£ -
Small	Significant	-	£ -	£ -
Medium	Low	2,914	£ 106,834,188	£ 107
Medium	Small	259	£ 9,486,288	£ 9
Medium	Medium	383	£ 30,208,721	£ 30
Medium	High	206	£ 39,493,615	£ 39
Medium	Significant	-	£ -	£ -
Large	Low	383	£ 8,242,667	£ 8
Large	Small	183	£ 12,847,347	£ 13
Large	Medium	478	£ 60,064,036	£ 60
Large	High	315	£ 58,240,214	£ 58
Large	Significant	-	£ -	£ -
Very Large	Low	-	£ -	£ -
Very Large	Small	109	£ -	£ -
Very Large	Medium	610	£ 126,848,304	£ 127
Very Large	High	341	£ 81,242,961	£ 81
Very Large	Significant	198	£ 220,490,559	£ 220
Total		77,102	£ 1,599,830,322	£ 1,600

A3.3.3 P2.1 Results Table

Table A3-8: Impact of installing RWH on 'large' and 'very large' buildings

Collection Area	Demand	Number of buildings	Impact	Impact (millions)
Large	Low	383	£ 8,242,667	£ 8
Large	Small	183	£ 12,847,347	£ 13
Large	Medium	478	£ 60,064,036	£ 60
Large	High	315	£ 58,240,214	£ 58
Large	Significant	-	£-	£ -
Very Large	Low	-	£-	£ -
Very Large	Small	109	£-	£ -
Very Large	Medium	610	£ 126,848,304	£ 127
Very Large	High	341	£ 81,242,961	£ 81
Very Large	Significant	198	£ 220,490,559	£ 220
Total		2,617	£ 567,976,088	£ 568

A3.3.4 UK flood risk assessment data

Table A3-9 provides a breakdown of the number of people and non-residential properties at risk of flooding in the each river basin area. It is noted that in regions where the number of people and properties are at risk the net cost of installing RWH systems in all new developments shows little benefit from reducing flood damage.

Table A3-9: UK flood risk assessment potential impacts by river basin

River basin area	Number of people at risk of flooding	Non-residential properties at risk of flooding
Solway Tweed	1,656	224
Northumbria	4,217	833
North West	25,476	3,008
Humber	64,082	10,296
Dee	17,213	13
Severn	17,213	2,031
Anglian	42,206	4,563
Thames	77,885	5,535
South West	33,151	5,330
South East	30,223	3,671

A3.3.5 P3: Results Tables

Table A3-10 Net impact of installing RWH systems linked to SUDs where SUDs is required

Collection area	Demand	Number of buildings impacted	Net impact (£)	Net impact (£ millions)
Large	Low	383	£ 12,395,641	£ 12
Large	Small	183	£ 15,942,123	£ 16
Large	Medium	478	£ 68,357,952	£ 68
Large	High	315	£ 62,164,446	£ 62
Large	Significant	-	£ -	£ -
Very Large	Low	-	£ -	£ -
Very Large	Small	109	£ -	£ -
Very Large	Medium	610	£ 135,456,847	£ 135
Very Large	High	341	£ 90,707,528	£ 91
Very Large	Significant	198	£ 226,298,753	£ 226
Total		2,617	£ 611,323,291	£ 611

A3.3.6 P5 Public building retrofit information

NOMIS provides data on businesses, broken down by size, location and industry. To access these options, all buildings where the purpose is 'public administration or defence', 'education' or 'health' have been considered.

As with previous policies, this gives data on the number of 'local units' a scaling factor has then been applied to attempt to discern the number of unique properties. For this policy option the scaling factor was reduced as it was deemed that public buildings, particularly buildings for schools, hospitals and doctor's surgeries are less likely be share with other businesses and more likely to be in self-contained buildings.

In addition to the larger number of buildings that would be impacted/ in need of retrofit. The key change to the next costs and benefits is the increased cost associated with retrofitting a RWH system. The analysis assumes shows that retrofitting the system increases the cost by 50% compared to installing it in a new build

Table A3-11: Total number of public building 'units' by region and size (number of people working there)

	East	East Midlands	London	North East	North West	
Total	23,985	18,315	37,330	9,235	27,590	
Micro	14,045	10,380	24,380	4,815	15,275	
Small	7,200	5,795	8,850	3,185	8,970	
Medium	2,500	1,955	3,555	1,095	2,975	
Large	240	185	545	140	370	
	South East	**South West**	**Wales**	**West Midlands**	**Yorkshire and The Humber**	**Total**
Total	36,640	22,810	13,035	21,195	20,335	259,945
Micro	21,525	12,915	7,085	11,865	11,135	148,625
Small	10,800	7,245	4,560	6,620	6,625	80,565
Medium	3,860	2,370	1,205	2,445	2,330	27,395
Large	455	280	185	265	245	3,360

A3.3.7 P5: Results table

Table A3-12: Net impact of retrofitting RWH systems in all public buildings in England and Wales

Collection Area	Demand	Number of buildings	Impact	Impact (millions)
Small	Low	3,336	-£ 29,127,649	-£ 29
Small	Small	6,671	£ 157,927,201	£ 158
Small	Medium	3,336	£ 233,143,042	£ 233
Small	High	-	£-	£ -
Small	Significant	-	£ -	£ -
Medium	Low	-	£ -	£ -
Medium	Small	3,493	£ 29,693,295	£ 30
Medium	Medium	6,985	£ 359,338,991	£ 359
Medium	High	3,493	£ 590,415,594	£ 590
Medium	Significant	-	£ -	£ -
Large	Low	-	£ -	£ -
Large	Small	-	£ -	£ -

Collection Area	Demand	Number of buildings	Impact	Impact (millions)
Large	Medium	6,073	£ 526,432,489	£ 526
Large	High	6,073	£ 962,099,290	£ 962
Large	Significant	-	£ -	£ -
Very Large	Low	-	£ -	£ -
Very Large	Small	-	£ -	£ -
Very Large	Medium	728	£ 102,067,880	£ 102
Very Large	High	728	£ 87,387,910	£ 87
Very Large	Significant	1,455	£ 1,044,975,523	£ 1,045
Total		42,371	£ 4,064,353,566	£ 4,064

A3.3.8 P5.1 Results table

Table A3-13: Net impact of retrofitting RWH systems in all public buildings with a collection area over 2000m^2 in England and Wales

Collection Area	Demand	Number of buildings	Impact	Impact (millions)
Large	Low	-	£ -	£ -
Large	Small	-	£ -	£ -
Large	Medium	6,073	£ 526,432,489	£ 526
Large	High	6,073	£ 962,099,290	£ 962
Large	Significant	-	£ -	£ -
Very Large	Low	-	£ -	£ -
Very Large	Small	-	£ -	£ -
Very Large	Medium	728	£ 102,067,880	£ 102
Very Large	High	728	£ 87,387,910	£ 87
Very Large	Significant	1,455	£ 1,044,975,523	£ 1,045
Total		15,057	£ 2,722,963,092	£ 2,723

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