TA.12.BR01 Bioresources Treatment and Growth
Business Case

September 2018
Version 1.0

1. Executive Summary

Name of business case	BR01 Bioresources treatment and growth
Context	• We produce 100% compliant sludge from 16 Sludge treatment centres (STC). • Industry benchmarking shows our delivery of the Bioresources price control is efficient, even though we use conventional treatment • We currently treat around 120,000 tonnes of dried sludge a year, recycling 100% of the compliant biosolids to agriculture. • We use the biogas produced from the treatment process to produce renewable energy. As a result three of our STC are energy neutral. • Through our biogas optimisation work we have outperformed our customer promise to maintain renewable energy production and are on track to end AMP6 at 17.5% renewable energy production.
Customer and stakeholder views	• Customers and stakeholders increasingly expect that we will generate energy (e.g. bio digesters of 'sludge' creating biogas) and use more sustainable energy technology at sites. • Our biosolids customers say they are happy with our product and see multiple applications for their land.
Our aim	a) Maintain our 100% compliant sludge treatment record b) Continue to recycle 100% of sludge to land as the best value option for customers, while aligning with our circular economy and resource hub ambitions. c) Meet AMP7 growth through transport solutions and working with the market to provide future growth needs post 2020 d) Increase energy production to 24% primarily through the replacement of our oldest CHP engines.
Scope of this business case	All investment within the Bioresources price control.

	Botex	**Enhancement**	**Total**
Totex (£'m)	£152m	£5.6m	£157.6m
Opex (£'m)	£77.7m	£0.8m	£78.5m
Capex (£'m)	£74.3m	£4.8m	£79.1m
Residual, post-AMP7 capex (£'m)	-	-	-
20 year Whole life totex (£m)[1]	£540m	-	£540m
20 year cost benefit (£m			
Materiality (% 5 year Totex for relevant price control)	-	-	100%

[1] Our whole Life costs and cost benefit figures have been calculated by extracting a 20 year portion of costs/benefits from a 60 year model. Further details are included in the TA 14.5-PR19 Approach to Optioneering technical annex

Relevant business plan table lines	WWS1 Lines 13 / 6	WWS2 Lines 3/50	
Botex-title			
Overview of AMP7 proposals	• We will invest £157.6 million to maintain our 100% complaint sludge treatment including £11.3 million for digester refurbishment and £21.5 million for CHP engine renewal. • We will invest £3.8 million to provide treatment capacity for sludge growth. We will work with the market post 2020 to develop future growth schemes. • We will invest £2.5 million at our Peacehaven Resource Hub site in new technologies to demonstrate the benefits of this approach		
Why are the proposals the best programme- level option for customers	• We have considered options at both programme and individual schemes. Programme options were considered for planned capital maintenance with our preferred option being lowest whole life cost. • We assessed over 30 advanced or innovative options as part of our Peacehaven Resource Hub development, selecting £2.5m of cost beneficial options for AMP7. Assessments included social and natural capital.		
What we would like to highlight	• We are developing our plans to provide sludge treatment services with Wessex Water at our Millbrook STC to enable the Shutdown of their Poole works. We are also exploring transport optimisation benefits between both companies. • We will transform our 16 STC into Resource Hubs, changing the way we operate, design and improve these sites to deliver greater benefits for our communities and the environment. We will start by investing £2.5 million at Peacehaven in new technologies.		
Enhancement – title			
Need for enhancement / investment	To provide treatment capacity to meet sludge growth in AMP7.		
Overview of AMP7 proposals	Our investment includes £3.8 million for population growth by removing transport constraints, maximising use of currently constraint capacity headroom. This proposal anticipates the opening of the market in 2020 as we will use this route to develop any future new digestion capacity.		
Why the proposals are the best programme-level option for customers	We have considered options to develop new digestion capacity, to unlock current treatment constraints to release latent capacity, and to provide transport solutions. The whole life cost assessment shows a combination of transport solution and unlocking latent treatment capacity is the cheapest option (£3.8 million compared to a cost of £28 million for new digestion capacity) This approach also provides flexibility to approach the market to develop new treatment capacity as and when it is required post 2020.		
Customer and stakeholder support	While not a high priority for customers, increased generation of renewable energy scored highly on willingness to pay (WtP).		
Need for a CAC	Not applicable		
Extent of management control (if relevant)	The costs are within our management control		

Robustness and efficiency	We have chosen the lowest whole life cost solution option for each investment line.
Customer protection (if relevant)	Our satisfactory bioresources recycling ODI is penalty-only. It provides for a maximum £12.5 million penalty if we drop below 97% compliant sludge treatment.
Affordability considerations	We have assessed whole life costs over 20 years for capital maintenance schemes.
Board assurance (if relevant)	This enhancement business case has been externally reviewed by Jacobs, with no material exceptions identified

Performance Commitments supported by this business case		
PC	**How relevant is this business case?**	**Comment**
Renewable energy generation	High	Investment in CHP renewal will increase renewable energy production to 24%
Satisfactory bioresources recycling	High	Capital maintenance and growth schemes will deliver 100% compliant sludge treatment

Contents

2. Scope of business case

This business case describes the investment in our Bioresources assets, including Resource Hubs, totalling £157.6 m in totex for AMP7. Figure 1 shows this in context of our £3.9bn PR19 plan.

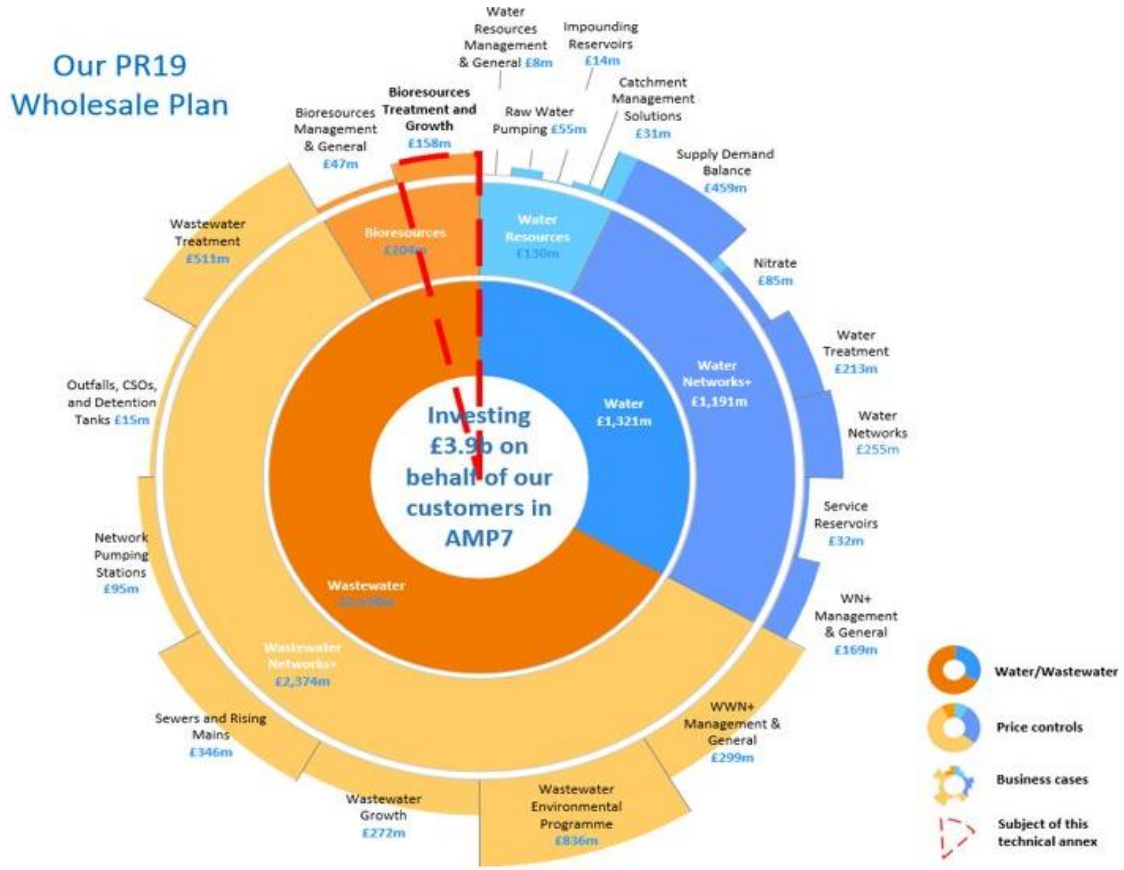


Figure 1 Southern water Wholesale PR19 investment plan[2]

This business case includes the following assets within the Bioresources price control (Figure 2):

- 16 Sludge treatment centres (STC)
- 18 Combined Heat and Power engines
- 41 Mesophilic Anaerobic digesters
- All dewatering and thickening activity at circa 200 wastewater works.
- All transport activities associated with Bioresources movement

[2] Figure 1 treats opex arising from AMP6 enhancement expenditure as ongoing enhancement spend in AMP7 in line with data tables WWS1 and WWs2. Our business cases, including this document, treat this as base expenditure.

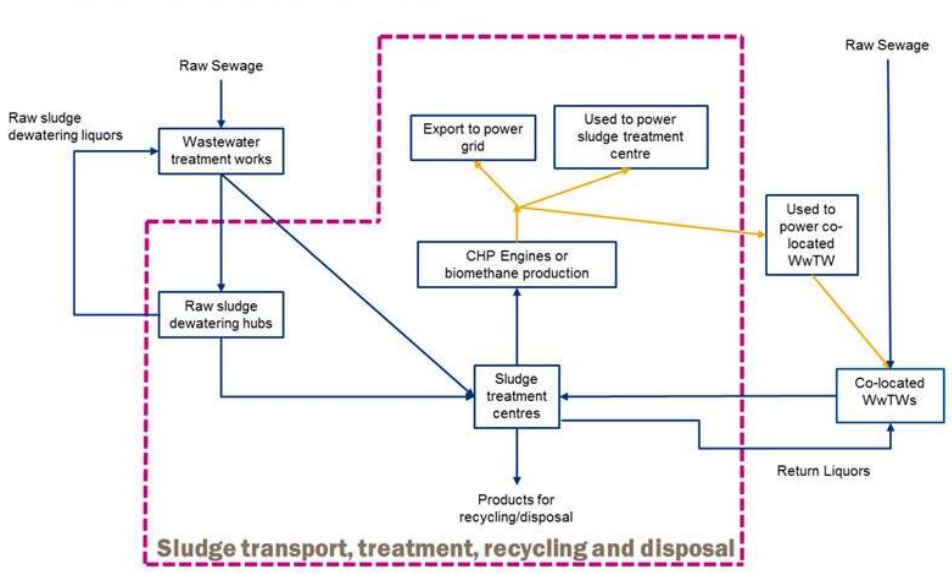


Figure 2 Bioresources price control[3]

The investment is split into the following AMP7 investment programmes:

- Capital maintenance and operating costs
- Energy from sludge schemes
- Sludge growth schemes
- Resource Hubs
- Regulatory metering

3. AMP6 Strategy

3.1 Investment Strategy

During AMP6 we are optimising our Bioresources asset base performances. As a result biogas production levels for conventional anaerobic digestion technology are among the highest in the sector. This focus means we:

- Recycle 100% of sludge to land, working closely with farmers on a targeted service
- Increased biogas yield whilst maintaining conventional digestion technology
- Target investment more efficiently
- Rationalised the number of STC from 18 in AMP5 to 16 in AMP6
- Use lime dosing over expensive drying technology at five STC, reducing energy use, carbon emissions and operational expenditure
- Created a dedicated optimisation team, empowered to deliver innovation with a spend-to-save budget

[3] Ofwat: Delivering Water 2020 consultation on PR19 methodology; Appendix 6: Bioresources Control

- Replaced four CHP engines with newer, more efficient engines to increase energy generation
- Introduced a biogas dashboard to enable gas flow against certain characteristics on site to be analysed
- Created strategic storage silos at Millbrook, Worthing and Hastings, optimising transport movements and reduce costs.

Table 1 AMP6 Actual and forecast expenditure

	AMP6 Actual (£m)					
	2015/16	2016/17	2017/18	2018/19	2019/20	AMP6 Total
TOTEX	24.701	28.228	26.192	32.685	30.777	142.583
CAPEX	7.838	10.309	11.710	16.737	14.748	61.343
Capital Maintenance	7.846	7.119	8.141	8.205	6.486	37.796
AMP6 Renewables[4]	0.277	2.857	2.640	0.246	0	6.021
Sludge - Growth Capex	-0.285	0.333	0.929	8.287	8.263	17.526
Opex	16.863	17.919	14.482	15.948	16.029	81.240
Sludge Maintenance Opex	16.752	17.972	14.307	15.327	15.391	79.748
AMP6 Renewables	0	0	0	0	0.223	0.223
CHP Renewal[5]	0.111	-0.053	-0.124	-0.232	-0.438	-0.735
Sludge - Growth Opex	0	0	0.299	0.853	0.853	2.004

Industry benchmarking shows our delivery of the Bioresources price control is efficient[6] . By operating our conventional digesters efficiently and adopting simple methods such as biocages, we achieved high treatment standards and biogas production without the need for costly investment.

3.2 Customer benefits & resilience

During AMP6 we have increased the proportion of energy derived from renewable sources, reduced our carbon emissions, upgraded STCs to use less energy than they generate, helped increase yields for farmers, limited tanker movements, reduced costs to customers, trialled the use of FOGs for energy production and boosted energy yields to match

4 AMP6 investment in renewable energy increases not including CHP renewal (e.g solar and dashboards)

5 CHP renewal capex included in capital maintenance line.

6 Unit cost analysis APR data and Oxera industry study

conventional digestion. This work has been recognised by accreditation for best practice and environmental stewardship.

3.2.1 Maximising renewable energy production from biogas

Increasing energy efficiency and renewable production is critical to increasing resilience and affordability for customers.

During AMP6 we have:

- Increased the proportion the proportion of renewable energy we use, from 15% at the start of AMP6 to 17.5%[7] in 2017/18. This exceeds our goal of maintaining Exceeding our commitment to maintain the proportion of renewable energy we use
- Gained Carbon Trust Standard certification for managing greenhouse gases – one of one a few water companies to do so.
- Been accredited to ISO 14001:2015 standard
- Moved half of our STCs to become net exporters of energy by the end of AMP6. Three are currently energy neutral
- Increased biogas yields at two STC. These sited are comparable in yield to advanced anaerobic digestion sites[8]
- Innovated new solutions, such as circular economy pilots and FOG trials at Ashford (adding fats, oils and greases to increase gas production)

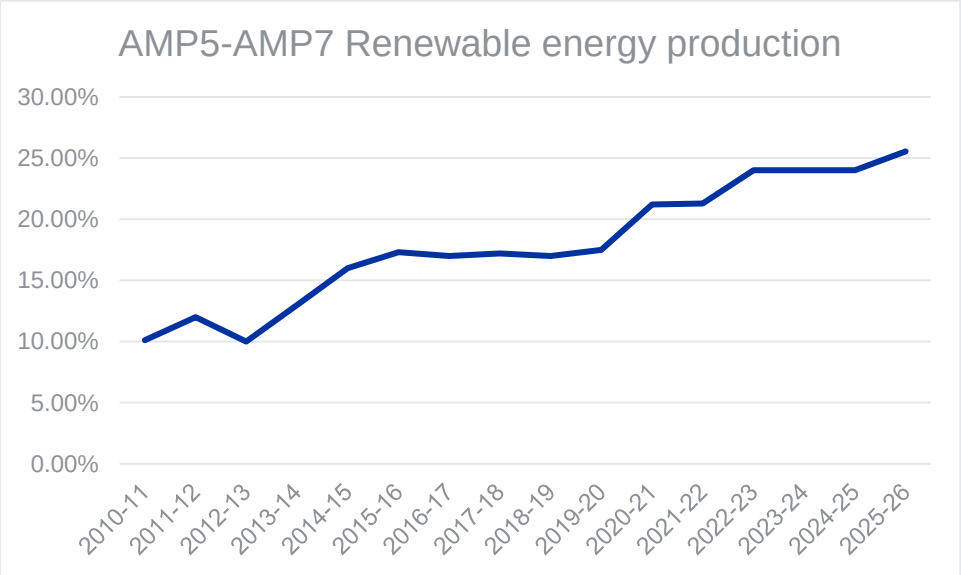


Figure 3 Proportion of energy from renewable sources

Source: 24042018 AMP7 Forecast renewables v0.xlsx

[7] This only refers to the energy we generate. Importantly, this does not include the 90% of imported energy which comes from renewable sources

[8] Motts Macdonald ; Strategic Review of Energy from Sludge Options.

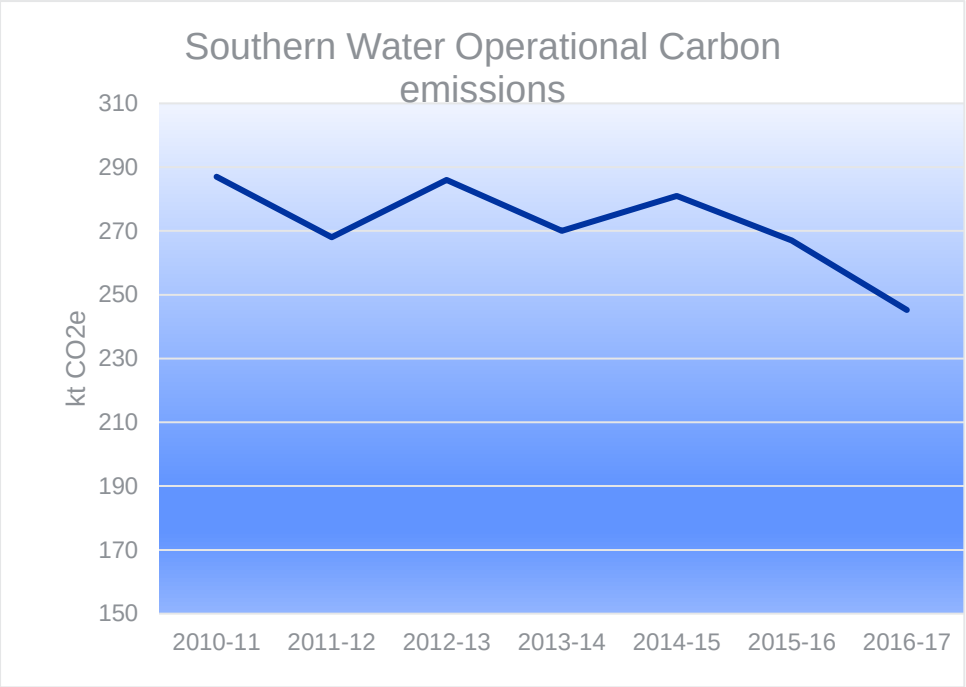


Figure 4 2010-2017 Total Southern Water Operational carbon emissions

Source: 24042018 AMP7 Forecast renewables v0.xlsx

The Biosolids Assurance Scheme now certifies that our Bioresources treatment and recycling activities meet regulatory requirements and best practice. We also commission an annual, independent audit to ensure we continue maintaining the scheme's standards.

Table 2 Compliant sludge recycling to land figures 2011-2017

Sludge treatment process	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17
% Sludge disposal route - sludge recycled to farmland	99.4%	100.0%	99.8%	100.0%	100.0%	100.0%

Source: Sludge disposal data 12.01.18.xls

Customer impact in AMP6

In addition to the above benefits operating our Bioresources treatment efficiently:

- Improves affordability for customers by reducing imported energy and tankering expenditure. Recycling 100% biosolids to land means reduces fees and provides a valuable, affordable resource for farmers
- Minimises the impact of tanker movements as much as possible, working closely with local authorities and customer groups
- Provides a tailored service for farmers. The quote below is from a farmer in Hampshire on the benefits he's found from using biosolids:

"Following an application, we get an immediate fertility improvement that lasts for two years". "We have not used any phosphate for several years, on fields we can treat with biosolids, saving some considerable amount."

4. Drivers for change

4.1 Future trends & pressures

The main future trends, pressures and opportunities for our Bioresources assets base can be divided into industry-wide, region-specific and company-specific.

Industry-wide:

- Competition in bioresources will drive innovation and cost reductions. We must remain flexible and innovate to compete effectively
- Regulatory changes will affect our energy strategy and ability to recycle biosolids to land. These includes:
    - The closure of the Renewable Obligation Certificates accreditation scheme, cutting income from the generation of additional CHP capacity
    - The Medium Combustion Plant Directive will require new cost-effective emission controls for new plants from December 2018 and existing plants by 2030.
    - Defra's new farming rules, in particularly the requirement for matching phosphorus applications to phosphorous uptake. This may increase the our total required landbank
- New and emerging energy technology is likely to alter the economics of energy scheme delivery, including from sludge schemes. More community energy projects and better battery storage improvements, for examples, both increase the viability of renewable energy production
- Greater understanding of risks from microplastics and pharmaceuticals in biosolids may affect our ability to recycle biosolids to land.

Region-specific:

- Greater collaboration with neighbouring companies may increase opportunities within the bioresources market
- Forecast population growth of 5.5 million by 2043, will increase the pressures on our Bioresources infrastructure, particularly treatment capacity headroom and landbank availability
- Competition for landbank in the north of our region could increase through growth, tighter regulation and demand from neighbouring companies

Company-specific:

- Conventional digestion technology reliance limits our potential biogas production

- Smaller STCs serving a relatively widespread population linked by few major road may limit economies of scale and potential biogas yields

To weigh these trends and pressures, we developed our strategy through a SWOT analysis. Our main conclusions are shown below:

	Strengths	Weaknesses
Internal	• Efficient production of biogas and renewable energy using conventional digestion • Distributed assets allows flexibility and incremental change • Large available landbank • Good working relationship with farmers to ensure land recycling of sludge • Mature optimisation approach to target the delivery of innovation within Bioresources. • Relatively optimised and efficient sludge transport arrangements • Strong customer support for increasing renewable energy production	• Reliance upon conventional technology constrains the volume of biogas that can be produced. • Distributed assets increase cost and requires more transport routes and increase costs • Widespread populations, few particularly large conurbations, East / West split • Few major road links across region or with other companies • Planning restriction for import to some large sludge centres
	Opportunities	**Threats**
External	• Opening sludge market provides more options for providing sludge treatment or utilising third party capacity. We have boundaries with two WASCs • Resource Hubs will transform how we treat bioresources to produce energy, minerals, and water • Use of food waste or energy crops to increase energy production (although regulatory constraints) • Growing market for small scale energy production • Rise of local community energy projects and financing provides opportunities to co-create energy at our STC.	• Increasing sludge throughputs due to population growth and larger quality programme • Increasing competition for landbank from neighbouring companies and tighter regulations • Increasing energy costs over the medium term • Regulatory constraints which limit restrict benefits from food or crop co-digestion • Potential risks to agricultural use from, for example, microplastics, and pharmaceuticals

4.2 Customer and Stakeholder insight

As outlined in Chapter 4 - Customer and Stakeholder Engagement and participation, we used insight from our extensive programme of customer and stakeholder engagement to develop a deep understanding of the views and priorities of our customers. All insight gathered from our customer and stakeholder engagement programme can be found in the technical annex to Chapter 4 - Customer and stakeholder engagement deliverables (TA.4.4).

Our customers believe we have a duty to protect and enhance the environment. They regard us not avoiding harm as an absolute minimum, but expect us to do more and protect and enhance the natural environment as part of our standard service. Customers ascribe a high priority to us avoiding pollution, and they expect sludge to be disposed of in a safe manner. They want water and wastewater services to be delivered in an environmentally friendly way now and in the future.

As environmental awareness increases, our customers increasingly expect us to use more sustainable energy and water sources, such as recycling wastewater. Stakeholders supported recycling water, but were divided about investment in renewable energy. Most environmental group representatives argued that this was vital while others, mostly councillors, believed that this entailed a cost that customers should not bear.

Customers regard carbon reduction and renewable energy use as important. Increasingly, they expect us to use our own wastewater services to generate energy (e.g. bio digesters of 'sludge' creating biogas) and to use more sustainable energy technology at our sites and assets (e.g. solar panels). Customers of the future place even more emphasis on protecting and enhancing the environment in the short and long term. They want us to use environmentally positive energy sources and believe renewable energy production is a medium priority. Overall, however, customers see investment in improving renewable generation as a low priority next to e.g. preventing flooding or leakage.

While most customers did not strongly prefer either the amount of renewable energy used or our carbon footprint as a measure of performance in this area, those who expressed a preference chose renewable energy as a more transparent and trustworthy metric.

Customers expressed strong support for recycling of waste for use as a fertiliser/soil conditioner. Similarly, stakeholders strongly supported more efficient, environment friendly options at our panels and in business as usual activities.

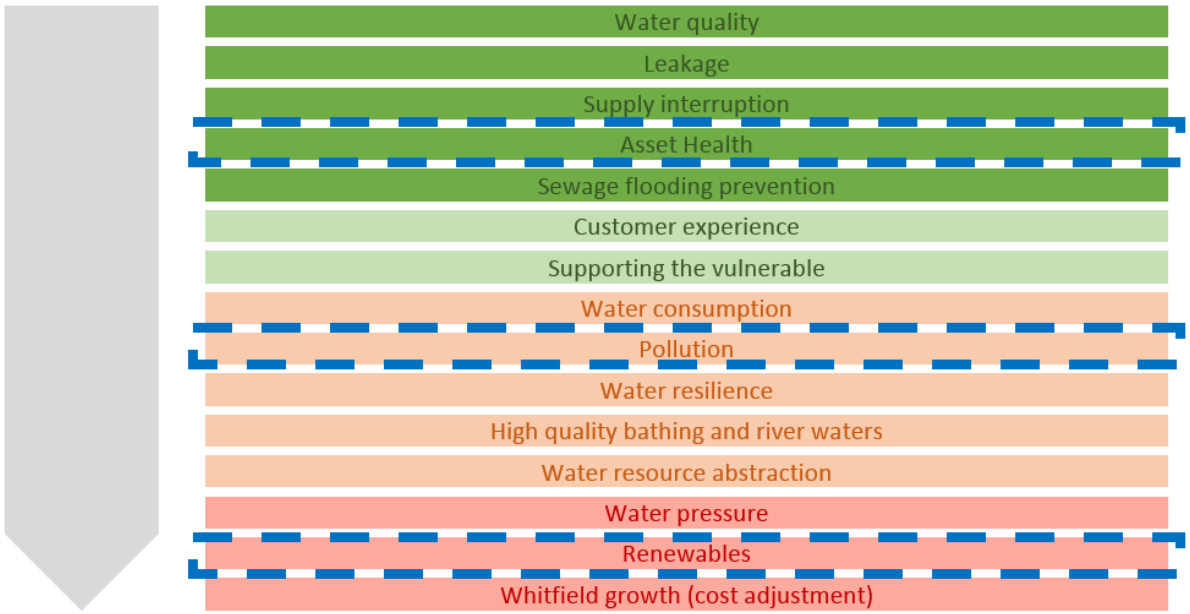


Figure 5 Relative priority of services according to our customers

The performance commitments outlined in this business case are based upon this engagement. They are how we will measure our success in meeting our customers' expectations and priorities.

5. AMP7 Strategy

5.1 Investment strategy

Our 25 year Bioresources strategy is described in section 5.7. From this is derived the AMP7 investment need to deliver a flexible approach, using the new market to deliver for customers.

	AMP7 (£m)			
	Price Control	QBEG	Ofwat Table	AMP7 Total
TOTEX				157.617
CAPEX				79.089
Capital maintenance: Named Schemes	Bioresources	Base - Non Infra	WWS1 13	11.299
Capital maintenance: Asset Interventions	Bioresources	Base - Non Infra	WWS1 13	2.493
Capital maintenance: Regional Programmes	Bioresources	Base - Non Infra	WWS1 13	13.440
Capital maintenance: Operational Direct	Bioresources	Base - Non Infra	WWS1 13	22.884
Peacehaven Resource Hub	Bioresources	Base - Non Infra	WWS1 13	1.690
CHP Renewal	Bioresources	Base - Non Infra	WWS1 13	21.454
Regulatory Metering Schemes	Bioresources	Base - Non Infra	WWS1 13/WS1 13	1.010
Sludge – Growth	Bioresources	Enhancement	WWS2 3	3.013
CHP Renewal- Growth	Bioresources	Enhancement	WWS2 3	1.807
Opex				78.528
Sludge Maintenance opex	Bioresources	Base - Non Infra	WWS1 6	87.220
CHP Renewal	Bioresources	Base - Non Infra	WWS1 6	-10.267
Peacehaven Resource Hub	Bioresources	Base - Non Infra	WWS1 6	0.786
Sludge - Growth	Bioresources	Enhancement	WWS2 44	0.789

Figure 6 Summary of investment in AMP7

5.1.1 Capital maintenance: Named Schemes

Our digesters are crucial to the production of compliant sludge, which generates the biogas needed for our CHP engines to produce renewable energy. During AMP6 we increased or maintained biogas production from these assets. Based on our deterioration modelling, these assets have a 15 year lifespan.

We regularly assess these assets, using our Asset Risk Management (ARM) system. To evaluate risks at sites approaching end-of-life. Specific risks include gas leakage, valve failure and seepage. Our overall assessment indicated that we will have to refurbish ten of the oldest digesters over AMP7.

Table 3 Digester asset base and refurbishment

Digester Name	Size (TDS/ Annum)	Last maintenance date	Digester Name	Size (TDS/ Annum)	Last maintenance date
Ashford 1	2800	01/01/2010	Ham Hill 1	1185	**01/11/2008**
Ashford 2	1550	01/08/2010	Ham Hill 2	1185	01/04/2014
Ashford 3	1550	01/07/2010	Hastings 1	2553	**01/11/2006**
Ashford 4	4119	**2008**	Hastings 2	2553	**01/05/2007**
Aylesford 1	1772	**01/04/2009**	Hastings 3	2553	**01/12/2008**
Aylesford 2	1772	**01/04/2009**	Millbrook 1	2600	2011/2012
Budds Farm 1	2790	2010/2011	Millbrook 2	2600	2011/2012
Budds Farm 2	2790	**2008/2009**	Millbrook 3	2600	2011/2012
Budds Farm 3	2790	**2008/2009**	Motney Hill 1	4500	01/06/2009
Budds Farm 4	2790	2010/2011	Motney Hill 2	2800	01/11/2007
Canterbury 1	1450	Pre 2000 (AMP6 scheme to refurbish)	Queenborough 1	1848	01/04/2006
Canterbury 2	1450	Pre 2000 (AMP6 scheme to refurbish)	Queenborough 2	1848	01/08/2006
Ford A	1848	01/10/2013	Sandown 1	1285	01/12/2013
Ford B	1848	01/10/2013	Sandown 2	1285	01/03/2014
Ford C	1848	01/10/2013	Sandown 3	1285	01/01/2015
Fullerton 1	850	01/01/2014	East Worthing 1	2220	**01/10/2008**
Fullerton 2	850	01/04/2014	East Worthing 2	2220	**01/01/2009**
Fullerton 3	850	**01/02/2004**	Peacehaven 1	3271	01/12/2012
Gravesend 1	2850	**01/01/2006**	Peacehaven 2	3271	01/09/2012
Goddards Green 1	1914	01/11/2014	Peacehaven 3	3271	01/09/2012
Goddards Green 2	1914	01/11/2013			

5.1.2 Capital maintenance: Asset Interventions

Building on the success of our AMP6 optimisation programme, we will continue investing to improve energy efficiency and reduce our carbon footprint. This also supports our Resource Hub improvements, maximising energy recovery from Bioresources.

5.1.3 Capital maintenance: Regional programmes

We direct investment in bioresources regional replacement schemes based on deterioration-modelled age-based asset interventions, typically resulting in simpler like-for-like replacements. We compare deterioration-modelled outputs against emerging and defined risks prioritised through ARM and subject to baseline levels of challenge and governance demanded by our Water Asset Lifecycle Process.

5.1.4 Capital maintenance: Operational direct

We will continue to fund capitalised repair and servicing costs based on historic levels of expenditure with an applied efficiency. As in AMP6, we will set aside this investment for our operational teams to direct a fast turnaround of work.

5.1.5 CHP Renewal

Our models show a ten-year asset life for CHP engines, an estimate being borne out by an increase in actual increased maintenance and declining utilisation. At certain sites, the size and reliability of engines is a significant constraint on the amount of energy generated.

We intend to counter this through the deployment of nine larger and more efficient replacement engines, capable of meeting future growth requirements. As a result a proportion of this investment is allocated to growth based on future population growth.

As a result, we expect to increase average MWh per TDS treated from 0.8MWh at present to 1.1MWh by 2025 (see table 4).

Table 4 Forecast energy generation and engine utilisation figures in AMP7

	2017/18	2018/19	2019/20	2020/21	2024/25
CHP Output - energy generated in MWh per Tons Dry Solids Treated (TDS).	0.834	0.834	0.867	0.867	1.112
CHP Engine utilisation	**75%**	**85%**	**85%**	**85%**	**90%**

Source: 24042018 AMP forecast renewables v0.xlsx

Power costs have been allocated between Wholesale Wastewater Network Plus and Wholesale Bioresources in line with regulatory accounting guidelines. Where there is only a single electricity meter at a co-located site, the power costs have been split using the power ratings of the sewage and sludge assets on site. Any sales produced by Combined Heat and Power (CHP) units are included in bioresources as income treated as negative expenditure

5.1.6 Resource Hubs

Our Resource Hubs strategy is described in section 5.2 as well as in the wastewater chapter. Peacehaven STC will be our flagship Resource Hub for AMP7 and is an ideal testbed. Biogas volumes reflect those from advanced digestion technology and the site demonstrates how we can deliver wider social benefits, such as the previous creation of a play-park, bridleway and habitat.

Following a detailed options appraisal assessment incorporating likely social and natural capital benefits, we have selected three cost-beneficial schemes to drive environmental sustainability and improve our social and natural capital at Peacehaven.

FOG Recycling

Building on our innovation-led trials at Ashford STC to increase biogas yields through the injection of Fats Oils and Grease (FOG) into digesters (initially importing used cooking oil). Subject to the success of those trials, we aim to by collect FOG from the catchment, increasing energy yield and reducing sewer flooding. See TA.12.WW07 Flooding and Pollution strategy for more detail on our plans to tackle FOG in sewers.

Battery storage

Improved battery technology enables us to use our generated energy at peak times, avoiding high-tariff consumption and enhancing resilience through reduced dependence on external power. By developing an innovative battery storage unit we can refine our energy management and improve potential cost efficiencies across the company.

Community hub

We want Resource Hubs to be closer to the heart of the communities they serve by providing community spaces such as meeting rooms or training centres. At Peacehaven, we will provide a space for training to build on ongoing apprenticeships and STEM ambassador training.

5.1.7 Regulatory schemes

Energy monitoring schemes

We are required measure each electricity meter to be re-tested or changed every 10 years to ensure accuracy and confirm payments. Table 5 lists those meters requiring such work during AMP7.

Table 5 PR19 Total No. Energy metering replacements required

Meter type	Number
Half Hourly meter exchange	389
Smart metering roll out AMR	1500
AMR meter exchange	2000

This investment is split between three price controls, with the most investment assigned within Wastewater Networks Plus (92.49%), followed by Water Networks plus (6.63%) and then Bioresources (0.88%)

Biosolids metering

The implementation of Water 2020 and associated regulatory accounting guidelines for the treatment of sludge/Bioresources requires more accurate measurement of sludge tonnage

treated at STCs. This, together with the emergence of a competitive market, makes the accurate measurement of TDS critical to the recovery of costs, In due course, we will also need to measure all TDS imported by, and exported to, 3rd parties.

Energy Opportunity Saving Scheme

The investment needed to comply with provisions of the Energy Saving Opportunity Scheme, requiring the assessment and energy saving identification for large undertakings and their corporate groups will enable us to meet our requirement to measure our energy use and identify cost-beneficial energy saving opportunities.

5.1.8 Sludge growth schemes

Based on forecast population growth and analysis of current capacity limits at our STC, we need to increase capacity to meet growth within Sussex and at Fullerton in Hampshire. We are also forecasting capacity shortfalls in Kent during AMP8, for which we will be seeking cost-effective market interventions from 2020.

Following an appraisal of options we will unlock existing constrained capacity at Budds farm, using this to treat Sussex sludge. We will meet the treatment deficit at Fullerton by transporting sludge to either Millbrook, or to Wessex Water.

Beginning in 2020, we will publish annual forecasts of sludge capacity volumes, inviting compare competitive tenders against our designed solutions. This will encourage innovative, cost-effective solutions.

After assessing numerous options, we intend to unlock capacity in AMP7 by optimising Bioresources transfers between sites. This is cost beneficial and allows time for market solutions to develop and be assessed.

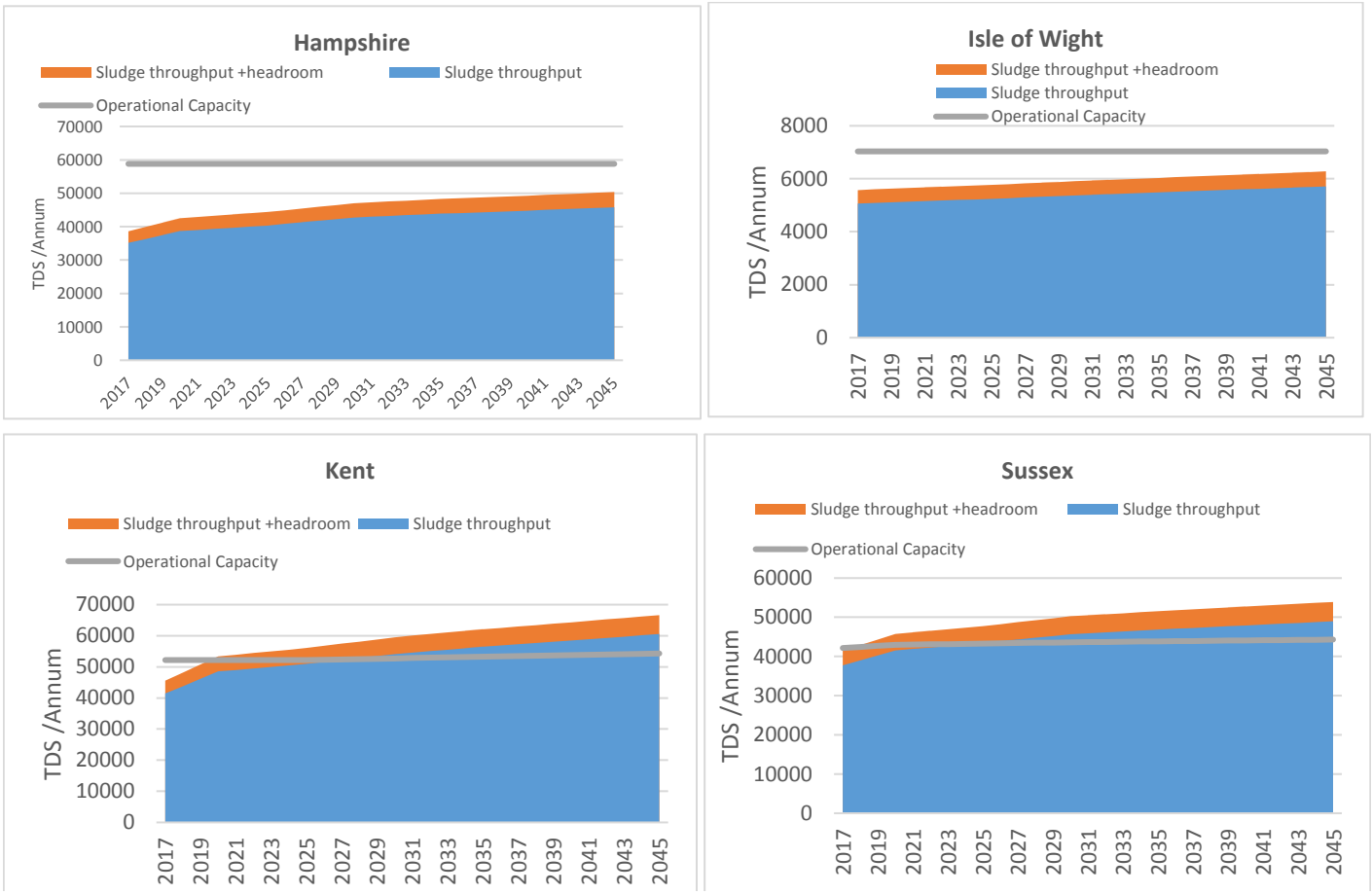


Figure 7 Projected sludge demand and capacity

Source: Bioresources master sheet v1.xls)

5.1.9 Sludge maintenance operating cost

Overall opex of £78.1 million is slightly lower than AMP6 expenditure, with additional energy savings offsetting an enlarged asset base.

Plan Options

We have optimised our AMP7 wastewater bioresources plan through the iterative development of options, grouped into programme level options, and scheme level options. These are discussed below.

5.1.1 Programme Options

We considered two principal options for investment in AMP7 bioresource capital maintenance.We modelled medium to long term impacts for each to ensure adequate levels of resilience, performance and affordability beyond 2025. Option 1 was based on unconstrained AMP7 investment to ensure stable service. Our second principal option was

based on deferring (referred to as constrained) investment to assess the consequences serviceability and whole life costs.

Option 1 was the preferred option with the lowest whole life cost (£304 million compared to £317 million for options 2). The overall impact of varying levels of AMP7 investment on affordability and resilience in future AMPs are assessed below.

Table 6 Totex Option summary

Option No.	Description	AMP7 Totex (£m)	Full Whole Life Cost (20 year NPV (£m) [13].	Willingness to pay support	Ofwat Priority	Other regulator priority	Customer priority	Business strategic alignment	Is this option recommended?
1	Unconstrained expenditure to maintain stable service	£93.3	**£304**	🟢	🟡	🟢	🟢	🟢	**Yes** – Offers stable service despite short term increases in increases customer bills this is the lowest long term cost option
2	Cost constrained in AMP7. Return to stable in AMP10	£90.8	**£317**	🔴	🔴	🟡	🔴	🔴	**No** -. Higher whole life cost and associated risks to performance commitments from deferring investment.

5.2.2 Scheme level options

Our detailed scheme options appraisal assessment was based on three key investment categories:

5.2.2.1 CHP engine renewal

We assessed whether using alternative technologies would be cost beneficial in the replacement of our oldest CHP engines. This review considered the following options:

Table 7 Summary of unconstrained energy from sludge options

	Technology	Description
1	Conventional treatment and CHP renewal	Retain our current digestion and biogas production set up
2	Conventional treatment and Biogas to grid	Replace CHP engines with gas to grid injection technology
3	Conventional treatment, biogas to grid and existing CHP using natural gas	Retain CHP and run using natural gas imports, whilst injecting biogas from digestion into the grid
4	Conventional treatment, CHP renewal and increased digester capacity for growth	Option 1 but allowing for larger digesters to be installed to meet growth

5	Thermal Hydrolysis Digestion Plant (THP) and CHP renewal	Switching to advanced anaerobic digestion technology to generate more biogas with CHP engines renewed
6	THP and biogas to grid	As option 5 but replacing CHP engines with gas to grid technology.
7	THP ,biogas to grid and existing CHP using natural gas	As option 5 but retain CHP and run using natural gas imports, whilst injecting biogas from digestion into the grid
8	Heating pasteurisation and hydrolysis HpH, biogas to grid and existing CHP using natural gas	Switching to advanced anaerobic digestion technology but retain CHP and run using natural gas imports, whilst injecting biogas from digestion into the grid
9	THP and Pyrolysis to increase energy generation (with CHP)	Retain CHP and use combination of THP and Pyrolysis technology to increase energy production and reduce sludge outputs
10	Food waste digestion	Co-deliver food waste digestion at or near our works with third parties (IOW council and energy co-operative in Brighton)
11	Energy crop digestion	Using energy crop to meet seasonal shortfalls in sludge throughput and maintain levels of biogas production.

Following detailed design, feasibility assessment and cost benefit analysis, renewing CHP engines was determined to be the best WLC model option. Table 9 below

details the wholelife cost comparison between gas to grid and CHP renewal, all other options determined to be non-feasible for our operations at present.

Table 8 CHP renewal option assessment

Site	Scheme description	20yr WLC	Selected
Ashford STC	Use existing and additional CHP-Ashford	-£21.2m	Y
	Biogas to biomethane for grid injection, existing CHP engines mothballed- Ashford	-£16.1m	N
Bexhill and Hastings STC	Use existing and additional CHP- Bexhill and Hastings	-£6.9m	Y
	Biogas to biomethane for grid injection, existing CHP engines mothballed- Bexhill and Hastings	-£1.1m	N
Budds farm STC	Use existing and additional CHP- Budds Farm	-£20.6m	Y
	Biogas to biomethane for grid injection, existing CHP engines mothballed- Budds Farm	-£7.3m	N
Motney Hill STC	Use existing and additional CHP- Motney Hill	-£6.1m	Y
	Biogas to biomethane for grid injection, existing CHP engines mothballed- Motney Hill	-£4.8m	N
	Use existing and additional CHP- Peacehaven	-£24.9m	Y

Peacehaven STC	Biogas to biomethane for grid injection, existing CHP engines mothballed- Peacehaven	-£9.6m	N
Sandown STC	Retain CHP- Sandown	-£2.9m	Y
	Mothball CHP and run biogas to grid-Sandown	-£2.8m	N
	Use existing and additional CHP to treat biogas from food waste and energy crops-Sandown	£18.3	N

5.2.2.2 Sludge growth

Based on our forecast we considered options to unlock existing capacity and create new digestion capacity. We designed, costed and appraised these using our WLC model, with results shown in table 10. This analysis showed using optimising biosolids transport and creating new reception facilities at Budds Farm was the most effective option. We will continually asses our growth forecast and options and share these with the market to enable the best WLC option to be developed.

Table 9 Summary of options investigated for sludge growth.

Driver	Scheme	SB	Iteration	WLC	Carried Forward
Sludge Growth Solution	Ford STC – Sludge (new capacity created)	757012	1	£24.5m	N
	Budds Farm Havant WTW / Sludge	757015	1	£2.2m	Y
	Fullerton - Millbrook transport solution		1	£0.05m (opex)	Y
	Goddards - Budds Farm transport solution		1	£0.8m (opex)	Y

5.2.2.3 Resource Hub development

We considered 32 possible technologies we could implement at Peacehaven. Following cost benefit analysis 3 schemes are included within this investment strategy:

1) Community Hub
2) Biogas increase through FOG injection into digesters
3) Battery Storage to make better use of renewable energy generated from biogas.

As noted, our approach during AMP7 must be flexible enough to take advantage of changes in technology and economics.

To fully support our Resource Hub approach, we incorporated natural and social accounting in the assessment of these schemes. This typically increased the level of cost benefit and turned the marginal cost beneficial community hub scheme into one with good cost benefit.

N.B the figures for FOG recovery are based on future technologies enabling 100% recovery of FOG from sewers and associated reduction in sewer flooding.

Table 10 Summary of the options appraisal process for resource hubs

	Initiative	Feasibility	Cost Benefit	
			20 year WLC modelling	Including social and natural capital
1	Portland Cement			
2	Gas-to-Grid			
4	Community Hub/Teaching Lab/Classroom		£0.45m	-£1.3m
5	Biogas Buses			
6	Conventional Thermal Hydrolysis Process THP			
7	Pyrolysis and Gasification			
8	Cryogenic			
9	Enhanced Frequency Response			
10	Grit recycling			
12	Cambi SolidStream			
13	Heat recovery (distribution to community (heating Saltdean lido, hospitals, schools)*		-£0.1m	-£5.8m
14	Water reuse and crops		WRMP	
15	FOG		-£0.15m	-£14.1m
16	Ultrasonic - internal			
17	DAF (grit screening)			
18	Green houses			
19	Thermoelectric generation			
20	Solar panels		Market led	
21	Wind turbines			
22	Hydro power/turbines/Reverse screws			
23	ASP-CON Strathkelvin			
24	Resource recovery			
25	Ostara			
26	Upstream Water Management (Rain gardens, SUDS etc.)			

27	New capacity for increased imports			
28	Battery storage		-£0.5m	-£0.005m
29	Additional Waste Management capacity			
30	Geothermal			
31	CO2 Sequestration			
32	Additional CHP		£1.3m	

***Wastewater networks plus price control**

5.1.2 Volume change impact assessment

In deriving this investment plan we have worked with a third party sludge optimisation modeling consultants to helps us develop long term views of changing sludge demand , to help us further optimize our operational costs and sludge transport operations. This also enables scenario testing. We have used this work to derive a unit cost figure to allow an assessment of the impact of treatment volume change upon our sludge operational expenditure, this is shown in the table below. Capex costs are fixed as changes in volume are likely to be spread across the region, they are therefore very unlikely to enable the closure or require new treatment facilities.

Sludge operating Cost		
AMP7 forecast gross (£m)	+/- 10% volume change impact (£m)	% impact upon sludge operating cost
87.22[9]	+/-4.07	+/- 4.7%

[9] See Figure 6 – sludge maintenance opex

Innovation

In a rapidly developing market characterised by the emergence of new technology, competition and regulatory requirements, our ability to innovate is critical to improving our operations and achieving greater efficiency. This section describes how we will leverage our bioresources strategy

Resource Hubs

A key component of our innovation-led 25 year strategy is to transform our larger treatment works into Resource hubs which reflect the true value of water by; generating renewable energy, supporting community amenities, recycling water and providing community spaces.

Resource Hubs will still treat wastewater to the highest standard – and will enhance resilience and the natural, social and economic capital of their communities.

Although not all aspects of Resource Hubs applies to our bioresources price control, key areas of activity are:

- Biogas optimisation programme, already providing the benefits to resource recovery of targeted spend-to-save investment and adopting innovative technology
- Maximising opportunities from co-digestion of sludge with food wastes or energy crops, focussing on local opportunities for partnership working
- Circular economy programme, including an Interreg[10] project examining resource recovery at wastewater sites
- Trials of new technologies to extract minerals from sludge to provide a sustainable fertiliser source. We will continue adopting new technology and methods, including capturing latent heat from sewers, final effluent and CHPs
- Integrated Water Cycle Management programme, taking a holistic view of our activities in catchments to increase social and natural capital. This will continue through Catchment First

Figure 9 below illustrates how we developed our approach for Resource Hubs.

[10] New Energy and Resources from Urban Sanitation

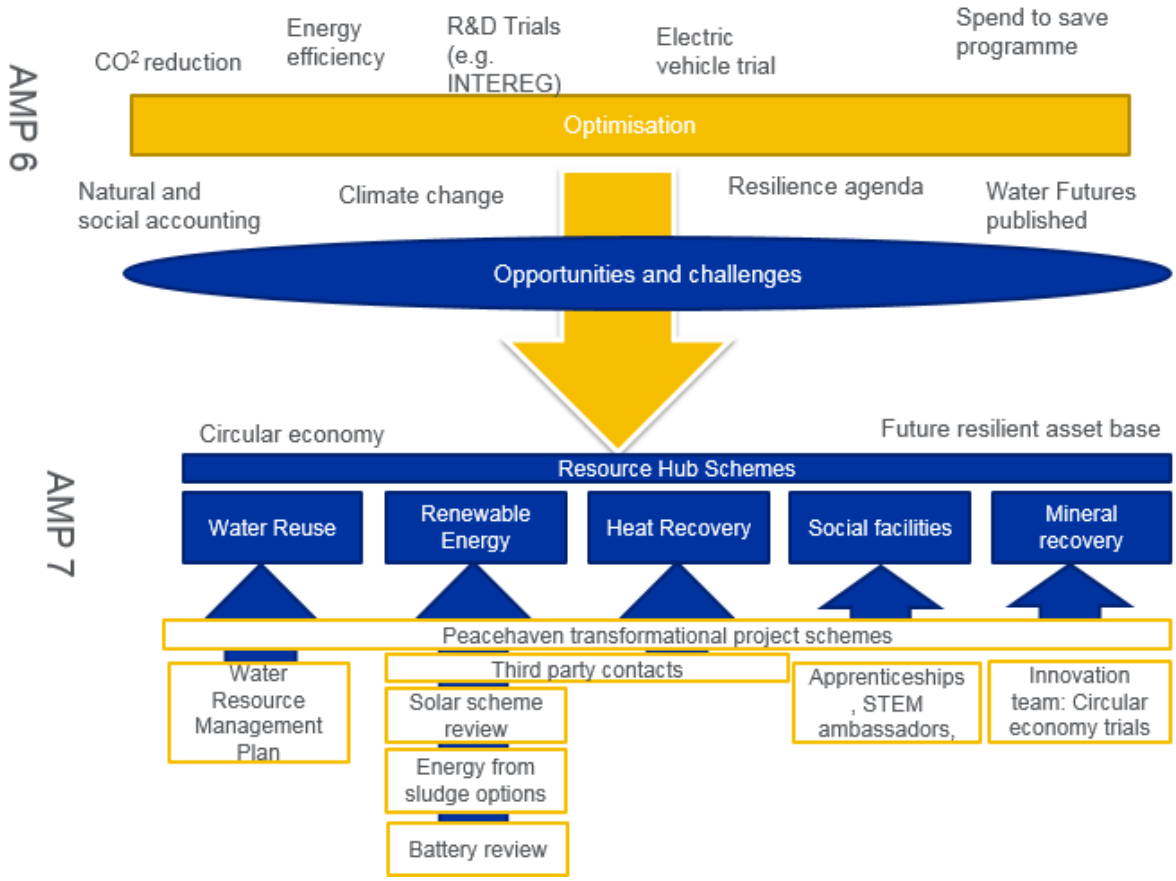
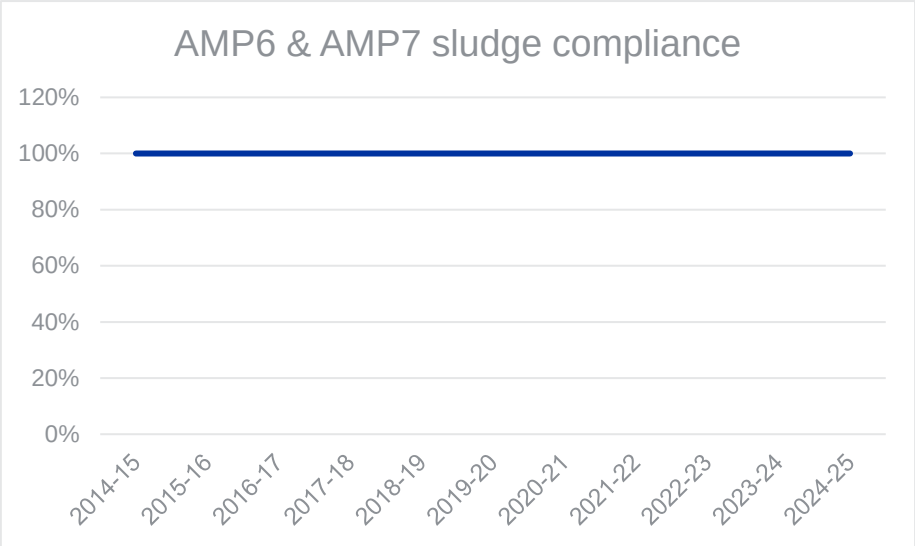


Figure 8 Development of our Resource Hub approach

All STC, to some extent, already have characteristics of Resource Hubs. Peacehaven will be where we will trial new technology and approaches. The first step in changing STC to Resource Hubs is renaming them, instigating cultural changes in how we operate, maintain and improve them. As we learn from Peacehaven, and share this insight with stakeholders, we will collaborate on other potential options across our region.

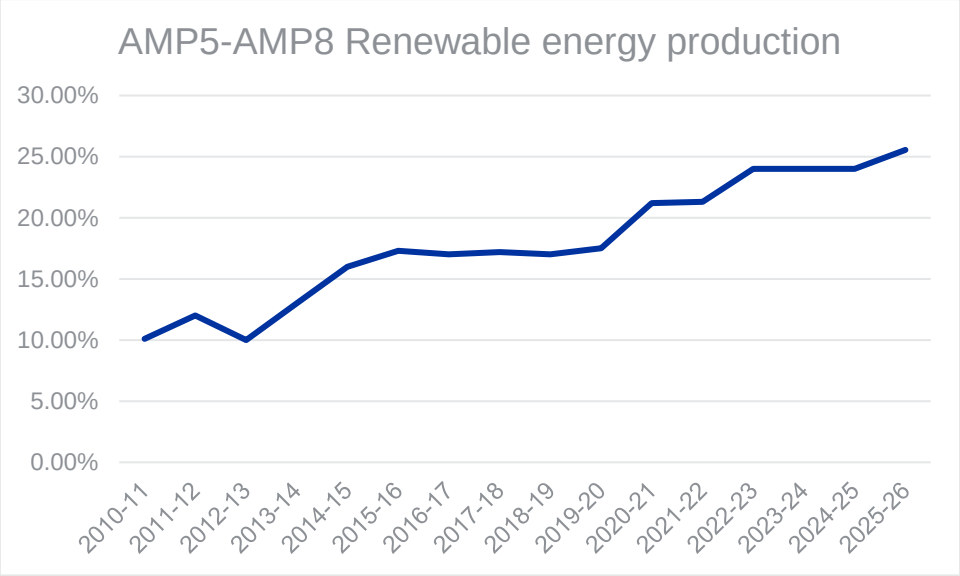
Customer benefits and resilience

Our Bioresources interventions will build on our AMP6 performance. We will increase the amount of renewable energy we generate by renewing CHP engines and optimising biogas production from our conventional digesters. Refurbishing digesters will remove risks and ensure we maintain 100% sludge compliance. Investing in strategic facilities to optimise biosolids transport will enable us to meet increased demand from growth, while maintaining flexibility to explore market solutions from 2020.



Source: Bio2 - Wholesale wastewater sludge treatment process and disposal routes

Figure 9 Actual and forecast sludge compliance in AMP6 and 7



Source: 240418 AMP7 Forecast Renewables.v0.xlsx

Figure 10 Actual and forecast renewable energy production in AMP6 and 7

The schemes in this strategy have been mapped against our totex resilience framework, with resilience broken down based on the Cabinet Office's 4Rs. This framework increases awareness of less conventional options to drive innovation and resilience strategies.

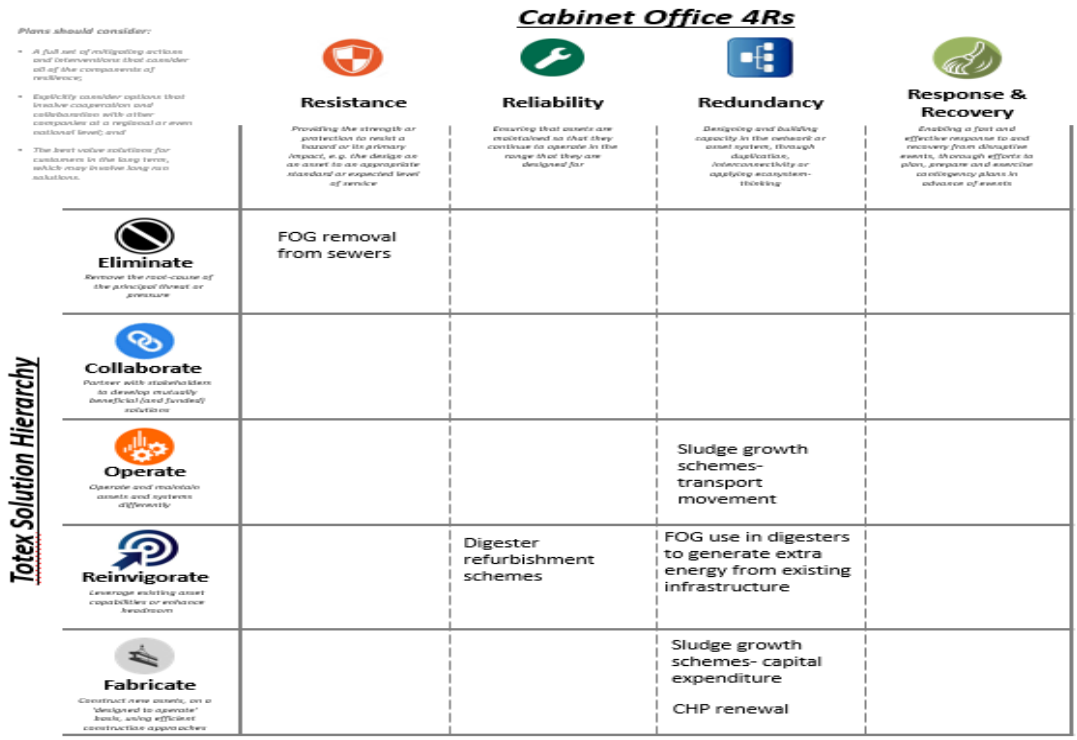


Figure 11 Totex resilience framework

Value for customers

Our triangulation of the relative priority of our proposed PCs showed the low and medium priority customers and stakeholders respectively ascribe to renewable energy, noting that the percentage of renewable energy is a medium priority for customers of the future.

Customers and stakeholders regard satisfactory bioresources recycling as a low priority However, there was significant variation in the priority placed on this measure between customer segments. While household customers placed low priority on this measure, vulnerable and business customers reported it to be a medium priority, and customers of the future regard it as high priority.

Customers will not accept reductions in service in exchange for lower bills, but are willing to pay for improvements in service levels for our proposed wastewater measures.

The total amount that SW customers would be willing to pay for a 1 percentage point increase in the proportion of SW's energy use generated using renewable sources was £2,794,802 per year.

Full detail on our customer engagement findings can be found in *Chapter 4 – Customer and Stakeholder engagement and participation.*

Table 12 Wastewater willingness to pay

Service Attribute	Unit	WTP [£/Unit/Year]		
		Central	Low	High
Use of renewable energy by Southern Water	% energy usage generated from renewable sources	£2,794,802	£2,134,698	£3,454,904

Our proposed strategy for meeting future sludge growth is to actively engage with and test market solutions in AMP7 to co-deliver cost-beneficial growth schemes. Reducing our energy expenditure on energy will support lower bills for customers.

Our preferred solutions will achieve delivery of two customer performance commitments:

- **Satisfactory Bioresources recycling**: ensure we continue our 100% compliant sludge to land recycling record
- **Renewable energy**: energy from biogas produces the majority of our renewable energy

Table 113 Bioresource performance commitment forecast

Performance commitment	Unit	17/18 performance	19/20 forecast	24/25 forecast	29/30 forecast
Satisfactory Bioresources recycling	**% compliance**	**100%**	**100%**	**100%**	**100%**
Renewable energy	% of our total electricity usage generated from our resources.	17%	17.5%	24%	28%

Costing Strategy

The costs shown in this business plan have been derived though the following approaches::

- Pioneer Deterioration Modelling (cost curve derived)
- Scheme Builder (cost curve derived)
- Historical Spend Projections (mostly opex and low value capex lines)
- Bottom-up assessment using historical performance (cost curve derived).

There are number of key deliverability issues that need consideration, including:

- Unlocking heat reuse is dependent upon multiple third parties agreeing contracts
- Delivering 2 digester refurbishments a year will place localised treatment capacity pressure on neighbouring STCs

6. Our Medium and Long Term Strategy

Bioresources will be subject to changing and intensifying pressures over the next 25 years, at the same time as opportunities will develop through the opening of the sludge market and growth in the circular economy. We must maintain flexibility in future strategies and make full use of the opening of the sludge market 2020 to deliver innovative, cost-effective solutions.

We have assessed a wide variety of options in the development of our plans for AMP7, confirming that best value is realised when a number of drivers come together in an area. For example, when growth requirements coincide with opportunities for recycling or co-digestion. Over the next few years we will pilot new ways of working through:

- Our Peacehaven Resource Hub
- Developing market opportunities and protocols with neighbouring companies, for example our plans to import and export sludge with Wessex Water
- Develop partnerships for community heat and energy initiatives, such as the Brighton & Hove Energy Services Cooperative

We will continue to assess investment opportunities but our next major upgrade for capacity is unlikely to be required until early AMP8. We intend to learn from our water resources planning and develop a bespoke real options appraisal tool. This will allow us to plan options which meet immediate needs and are adaptable and resilient against future uncertainties.

In the tool, decision points are defined through risk and opportunity trigger analysis and range from a capacity shortfall to a projected shift in energy prices or technology readiness levels.

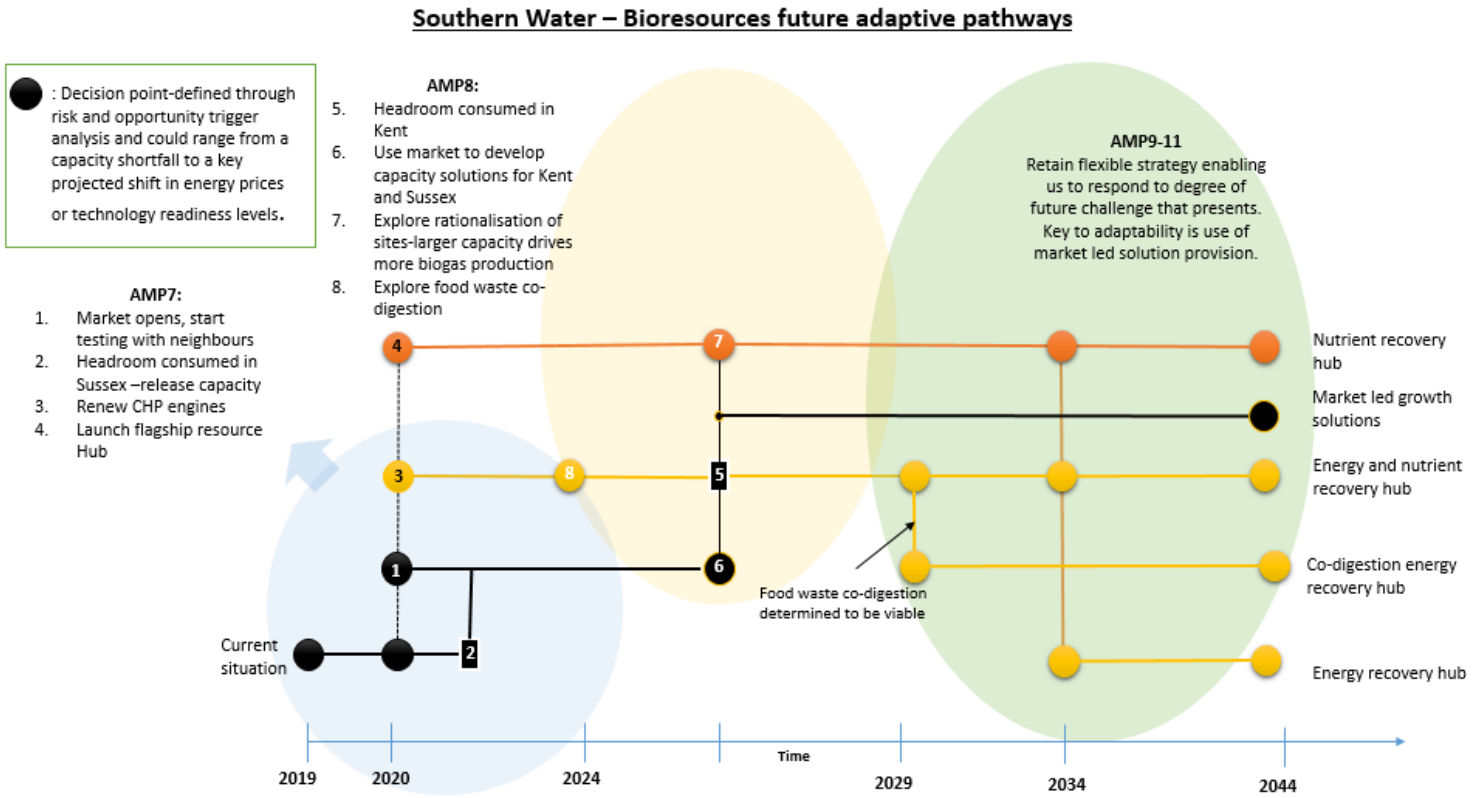


Figure 12 Example adaptive pathway strategy for Bioresources

6.1 Medium term plans-AMP8

Our current projections show Kent will experience capacity shortfalls during AMP8. From 2020 we will explore cost-effective, collaborative market interventions to secure additional capacity. If delivered internally, in addition to extra treatment capacity our solution would likely involve developing new strategic reception facilities, the release of key operational constraints and seeking a change in planning consent. We are investigating possible economies of scale by rationalising 5 STC in North Kent, adopting advanced digestion technology and optimising transport routes.

Our proposed sludge growth investment will meet AMP7 demand in Sussex. However, based on forecasts, we will require additional treatment in AMP8. We will actively work with the market and third-parties to develop collaborative, cost-effective solutions – including a solution for growth in both Kent and Sussex

We have developed a strategic planning tool which will allow us to optimise our network over different timescales – from planning weekly transport schedules to providing a 25 year view of sludge growth and preferred options to meet it. This tool will be crucial when assessing third- party options.

AMP8 will see further roll out of Resource Hub approaches. Depending on the outcomes from trials at Peacehaven, we could quickly expand heat recovery from treatment processes to different sites across the region.

We anticipate food waste to form a key component of Government's waste strategy, expected in November 2018. Following our own work for inform AMP7 we will continue working with stakeholders and communities to understand the potential for co-digestion across the region.

6.2 Long term plans AMP9-11

Beyond AMP8 we will remain flexible and will use adaptive decisions pathway techniques and real options to identify the most advantageous strategy dependent upon which risks manifest.

Our long term strategy is based on four key themes illustrated in Figure 14, below:

- Process optimisation – continuing to improve efficiency and performance
- Capacity enhancement – using the market to maximise opportunities to meet high levels of growth in the region
- Resource Hubs –greater use of renewables, reuse and recycling, while exploiting natural resources from more sustainably and efficiently. Changing energy prices and technological developments will render advanced energy generation from sludge techniques more cost beneficial. Based on our innovation work on nutrient recovery, we expect this technology to reach maturity in AMP8 and 9 adding an additional stream to our Resource Hubs
- Supporting agriculture – ensuring we provide the service and products that support farmers and agriculture. Our joint working with Southampton University is enhancing our knowledge on soils, such as the risk from microplastics.

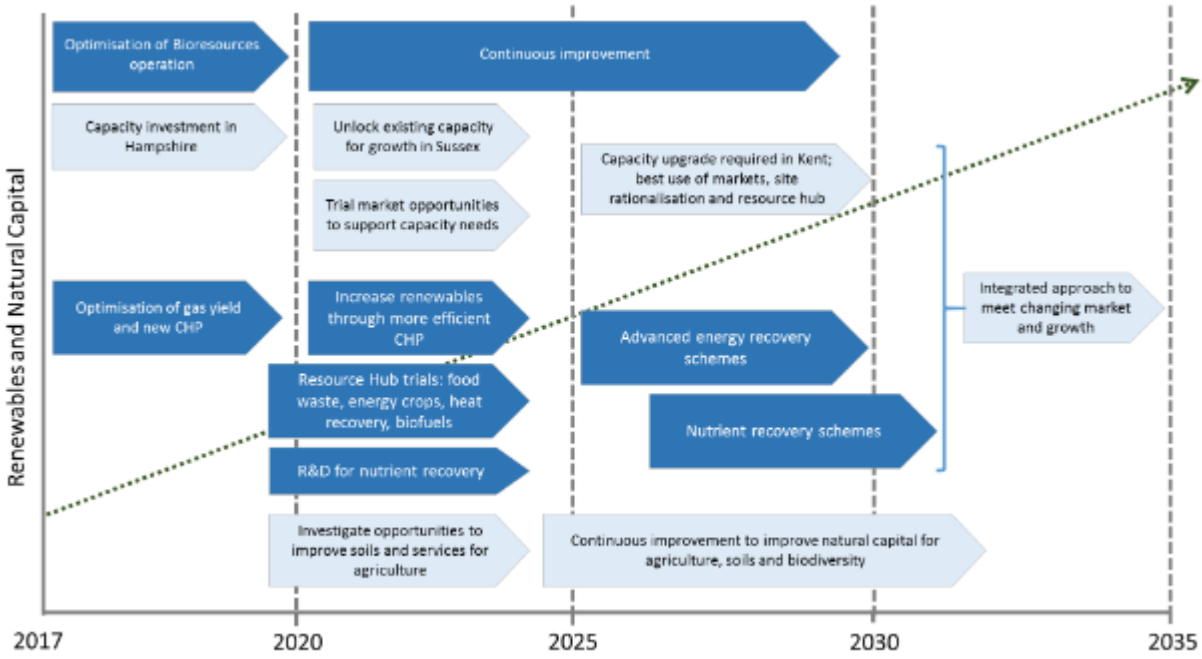


Figure 13 : Indicative 25 year view for Bioresources compliance, growth and resource hubs

We expect key decision points to be triggered by the need to renew our existing asset base as well as capacity constraints

Table 14 Projected bioresource investment up to AMP9

	AMP6	AMP7	AMP8	AMP9
TOTEX	142.583	157.617	162.379	162.628
CAPEX	61.343	79.089	85.204	85.452
Opex	81.240	78.528	77.176	77.176

6.3 Sludge Market opening in 2020

Markets deliver cost-effective outcomes for customers. The sludge market opening is a substantial opportunity for our long-term planning. We will exploit it to develop and deliver innovative schemes.

We see the market as important to three key benefits for our strategy:

- Resilience provision – agreements with neighbours to provide sludge treatment assistance if required in the event of asset failure
- Sludge logistic optimisation
- Purchase of treatment service requirement

We have begun detailed discussions with Wessex and Thames Water about options to use market mechanisms in Hampshire. We will begin market-led sludge trade during AMP7 and see this as a way to maintain bill affordability and increase resilience for customers.

Wessex Water is in the process of planning and undertaking capital maintenance at Poole STC, restricting treatment capacity for an extended period. We are developing options to utilise available capacity at our Millbrook works to import sludge from Wessex during this maintenance period.

We also forecast Fullerton STC having a small deficit by 2024. A number of sites in the Fullerton catchment are close to Wessex Water's Ratfyn STC representing an opportunity to use market mechanisms to remove constraints at Fullerton.

We will regularly update and publish our forecast sludge capacity, allowing external providers a view of our likely requirements and to aide submission of competitive tenders to deliver solutions

7 Key Risks and Opportunities

7.1 Risks

- There is a risk that legislative change, such as new engine emission standards, changing tax rates on bio-fuels or the withdrawal of ROC incentives will introduce inefficiencies.

This could occur as these uncertainties mean that investment in new plant is harder to justify or future changes require existing plant to be de-commissioned prematurely.

- There is a risk that in AMP7 sludge volumes will grow at a faster rate than we have assumed. This might occur because of faster than expected economic growth or new plant and discharge consents may increase levels of sludge generated above those predicted. This will require additional expenditure during the AMP7 period.

- There is a risk that we may lose access, at short notice, to our landbank which would disrupt recycling and lead to significant additional haulage and sludge recycling and disposal costs. This could occur due to range of factors, such as changing retailer or farmer preferences, sudden changes in farming subsidies, outbreaks of disease such as Blue Ear or Mad Cow Disease or exceptionally long cold winters.

7.2 Opportunities

- There is an opportunity to further increase the efficiency of sludge treatment above that assumed by entering into additional sludge treatment and recycling contracts with adjacent water companies and waste management companies. This may allow greater economies of scale and additional flexibility in times of disruption.

- There is an opportunity to increase renewable energy generation above those levels already assumed in these proposals leading reduced costly energy imports and improved affordability for our customers.

- There is an opportunity to install Energy-from-waste technologies to increase the amount of renewable energy we generate. This increases our resilience by reducing dependency on the grid. It will also ensure we remain competitive in a future decarbonised economy.

- There is an opportunity to design, test and deploy a range of new community services at a higher rate than we have assumed in these proposals. Through the accelerated provision of district heating schemes, the recovery of heat from effluent and community water re-use services we may be able to deliver enhanced levels of efficiencies and deliver more services to our communities than we currently predict.

Appendix 1: Schemes in AMP7

Scheme Name	AMP7 Capex Total	Total AMP7 Opex AFC	AMP7 Totex
Ashford STC - MNI	1.311	0	1.311
Aylesford STC - MNI	1.492	0	1.492
Budds Farm Havant STC - MNI	1.029	0	1.029
Fullerton STC - MNI	0.506	0	0.506
Gravesend STC - MNI	0.872	0	0.872
Ham Hill STC - MNI	0.728	0	0.728
Hastings STC - MNI	1.443	0	1.443
Motney Hill STC - MNI	1.796	0	1.796
Queenborough STC - MNI	1.055	0	1.055
Peacehaven Resource Hub	1.690	0.786	2.476
Worthing STC - MNI	0.863	0	0.863
Ashford STC - Carbon	5.158	-2.039	3.119
Aylesford STC - Carbon	2.063	-0.577	1.486
Budds Farm STC - Carbon	2.971	-1.796	1.175
Canterbury STC - Carbon	1.982	-0.720	1.263
Worthing STC -Carbon	1.982	-0.625	1.358
Ham Hill STC - Carbon	2.095	-0.435	1.660
Millbrook STC - Carbon	2.537	-1.070	1.468
Motney Hill STC - Carbon	2.490	-1.589	0.901
Queenborough STC - Carbon	1.982	-1.618	0.365
Budds farm capital scheme (from schemebuilder)	3.013	0.050	3.064
	39.058	**-9.630**	**29.43**