Imperial College London

Greywater Recycling with and without Solar Power – a Technical and Economic Feasibility Study.

Timothy Munday

Final Year Project, Civil and Environmental Engineering, Imperial College London

WATER SCARCITY AND WATER USE

Water scarcity occurs in areas where the **demand** for water is **greater than** the **supply**. It is a growing problem **globally** but its effects are often local.

Water scarcity can be exacerbated by:

- Increases in local population
- Higher per capita water use driven by improving lifestyles
- Uncertainty due to climate change

The problems associated with water scarcity can be overcome by either **increasing supply** or **reducing demand.**

In the UK the daily domestic water use is **150**l per capita.

Greywater Recycling Schemes reuse lightly polluted domestic water for non-potable uses. This can reduce water demand by **33%**.

THE SITUATION IN THE UK

- **Water scarcity** is a problem in much of the South East.
- Limited housing availability requires a significant number of **new homes** to be built. Many will be built in large residential developments on the edges of existing settlements.

GREYWATER RECYCLING SYSTEMS (GRS)

- Various proven technologies of which **Constructed Wetlands** and **Membrane Bioreactors** are attractive options
- Suitable for use in a **decentralised** manner
- Overall sustainability improved by providing energy with **solar generation**

MEMBRANE BIOREACTOR (MBR)

Greywater is mixed within a bioreactor before being drawn through an immersed membrane filter.

Benefits:

- Small footprint
- Requires little additional treatment

Issues:

- Energy intensive
- Susceptible to membrane clogging

CONSTRUCTED WETLANDS (CW)

Greywater is pre-treated, then passed vertically through the media of **vegetated beds** before final disinfection.

Benefits:

- Minimal operative costs
- Additional environmental impacts

Issues:

- Sensitive to land prices
- Requires supplementary treatment

PHOTOVOLTAIC PANELS

Benefits:

- Suitable for onsite decentralised generation in most locations
- Income from feed-in-tariff

Issues:

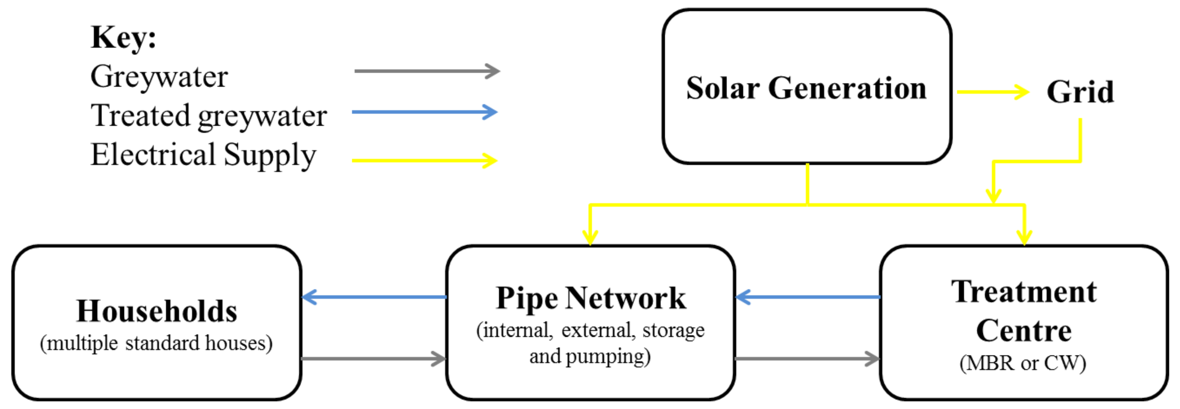
- Unable to provide electricity at night, so still requires connection to mains electricity

MODELLING A GRS FOR A RANGE OF SIZES OF RESIDENTIAL DEVELOPMENTS

A model is needed to calculate the **costs and benefits** associated with the users of a GRS. The model is created such that the size of development being considered is easily varied.

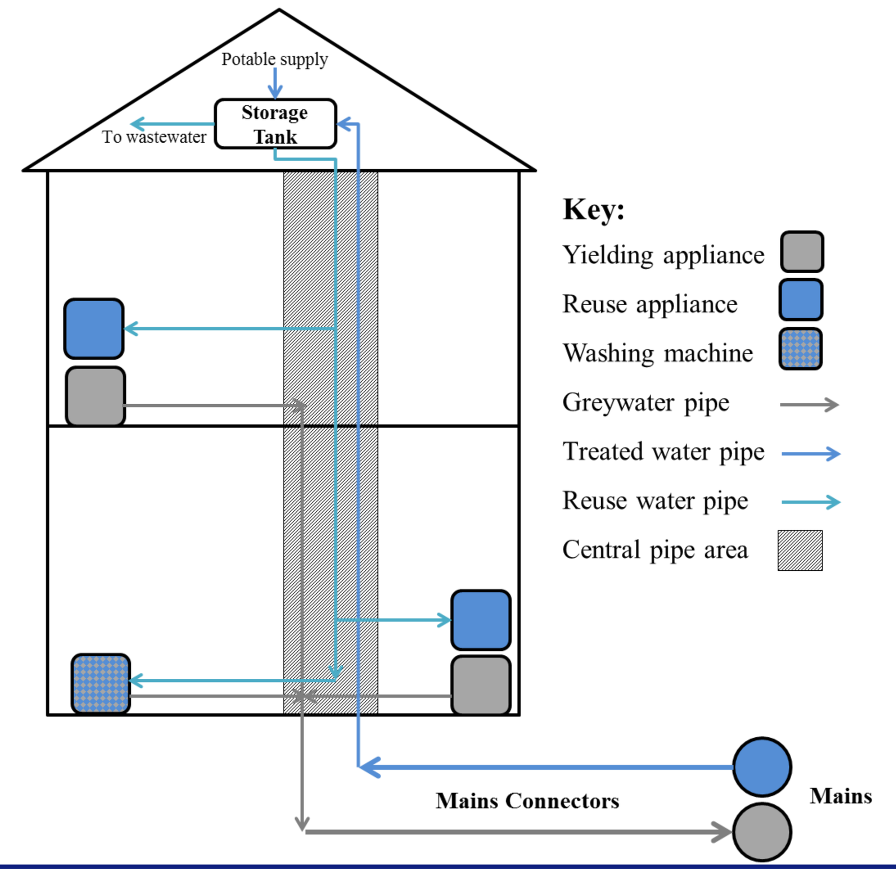
A **representative scenario** is developed to imitate the characteristics of an average development.

This is used to give a **general relationship** between the **number of households** within a development and the **economic feasibility** of a particular GRS technology combination.



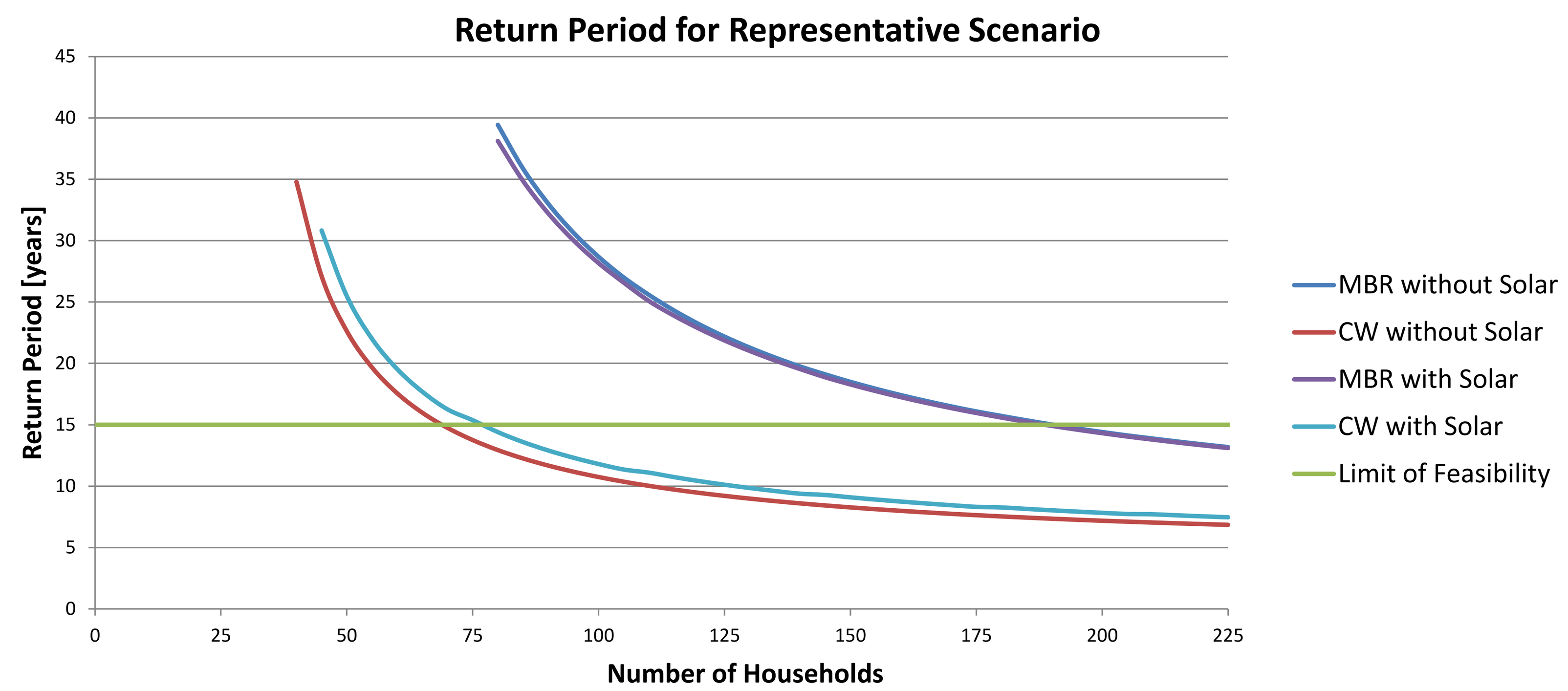
The model is arranged into four changeable sub-models allowing **different technology combinations** to be considered.

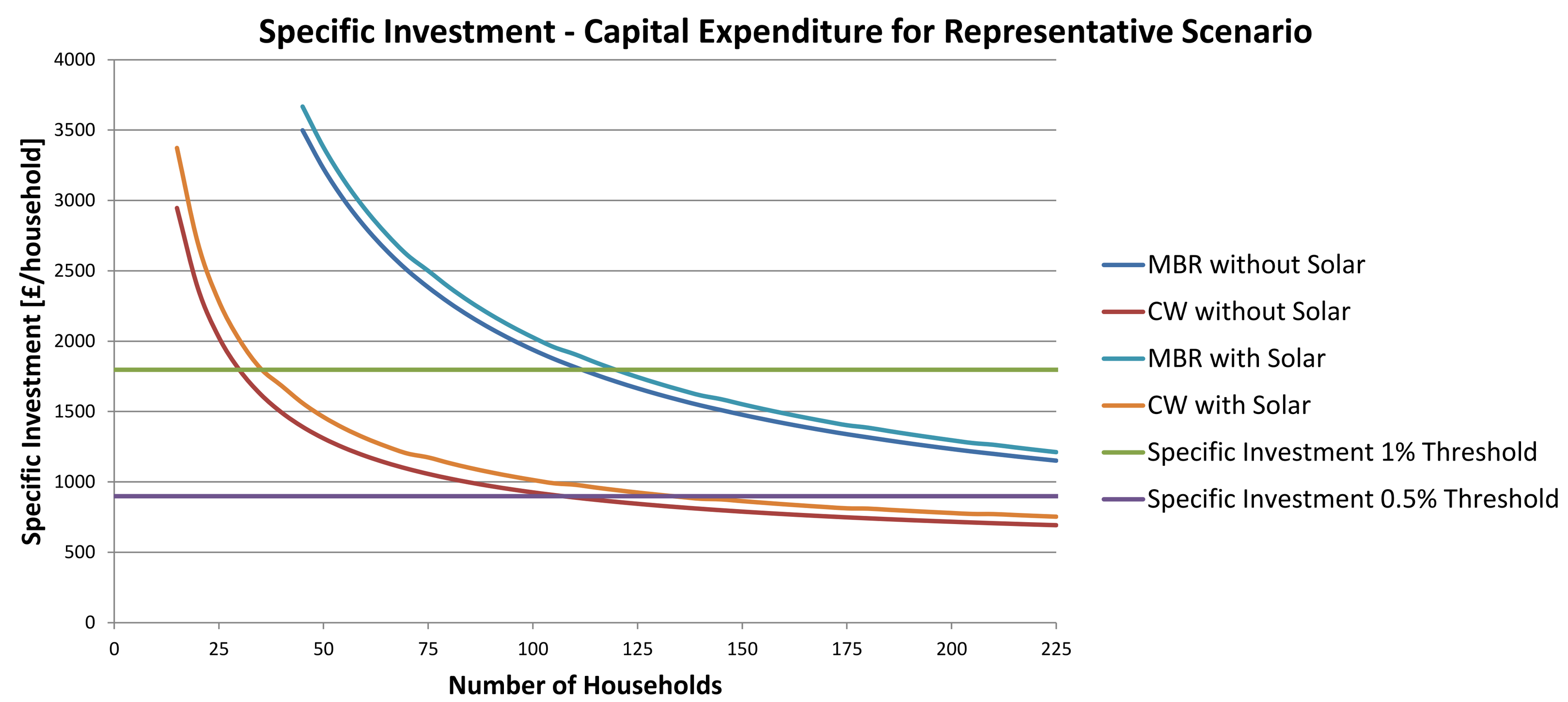
Representative scenario uses a **standard household design**. This and other aspects can be altered to model specific schemes



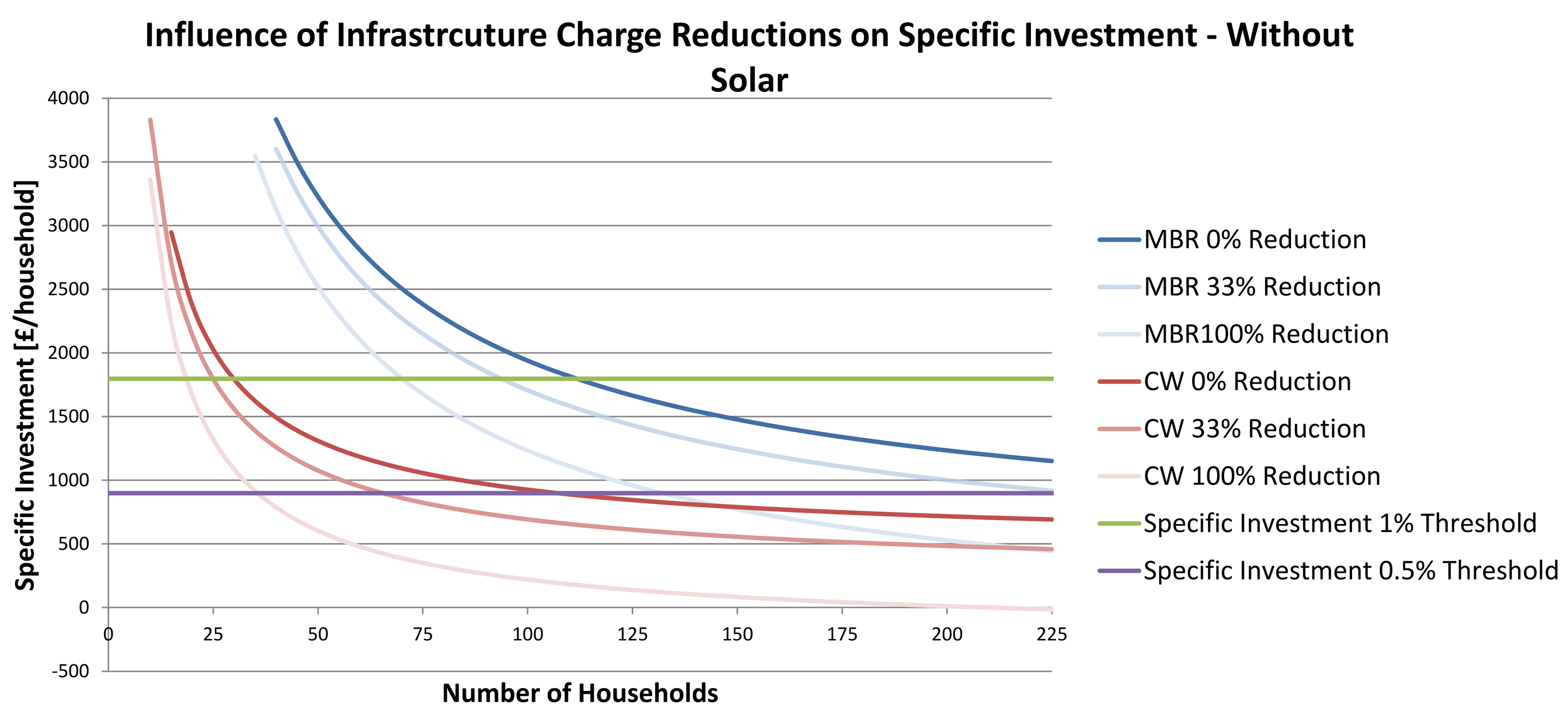
POINT OF ECONOMIC FEASIBILTY AND SPECIFIC INVESTMENT FOR DIFFERENT TECHNOLOGIES

A project is deemed to become economically feasible when the time taken to repay the costs is less than the operative lifetime of the scheme, taken to be 15 years[1] . The specific investment per property should also be less than 1% or 0.5% of the average properties value.





INFRASTRUCTURE CHARGE



This is a charge levied by water service providers for new connections to either the water or sewage network and is currently set at £353[2].

CONCLUSIONS

1. A **MBR system** with solar and without solar becomes economically feasible for developments with **191** and **189** houses respectively.
2. A **CW system** with solar and without solar becomes economically feasible for developments with **69** and **77** houses respectively.
3. At the point of economic feasibility the specific investment per household for a **MBR system** with and without solar is **£1343** and **£1277** respectively. For a **CW system** with and without solar this is **£1102** and **£1158**.
4. Waiving part or all of the infrastructure charge has a significant effect on the economic feasibility of both systems.

REFERENCES

[1] Friedler and Haradi (2006) *Desalination*. 190 (1-3), 221-234
[2] Thames Water (2015) *Charges Schedule* [Online] Available from: http://www.thameswater.co.uk/tw/common/downloads/literature-water-waste-water-charges/Charges_schedule_2015-2016.pdf [Accessed 23rd July 2015]