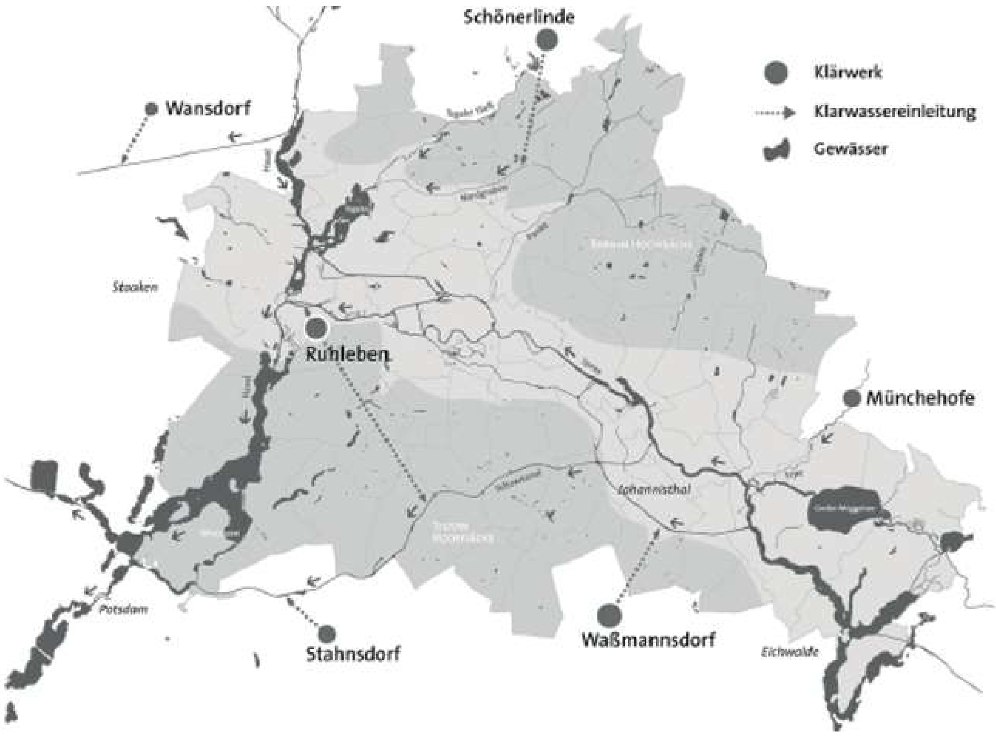
CASE STUDY GERMANY

3.4

3.4.1 Description of Wastewater Treatment Plant

The selected WWTP is one of the six treatment plants in Berlin operated by the Berlin Water Works (Berliner Wasserbetriebe - BWB). The selected plant treats wastewater of approx. 230,000 m3/d (dry weather capacity) correlating to approx. 1.6 Mio. population equivalents as COD load (BWB, 2018).

Figure 3.3
Location of Berlin's WWTPs and effluent discharge points (BWB, 2019)



The plant uses a conventional approach with mechanical and biological treatment, nitrification and denitrification, biological phosphorus elimination, mesophilic digestion and utilization of biogas in CHPs for heat and electrical power generation.

3.4.2 Selected scenarios by REEF 2W decision support tool

For a first evaluation the REEF 2W decision support tool was used as described in **Appendix 5**. Based on the outcomes of this evaluation, three different scenarios (see Table 3.6) were selected for a more detailed analysis in the Berlin case study.

Table 3.6
Selected scenarios for detailed analysis after screening with REEF 2W decision support tool

Scenario	CHP	Biogas upgrading system	Electrolyser for PtG
Status quo (I)	6 MW	0 m^3/h biogas	0 MW
Scenario II	0 MW	1,800 m^3/h biogas	0 MW
Scenario III	0 MW	1,800 m^3/h biogas	7.8 MW

3.4.3 Results and Discussion

Energetic point of view

The detailed energy analysis was carried out with a dynamic model, developed by Kompetenzzentrum Wasser Berlin. The model was developed in Microsoft Excel due to its ubiquity, usability and portability of the created files.

Figure 3.4
Screenshots of user interface as well as results gained by the dynamic model

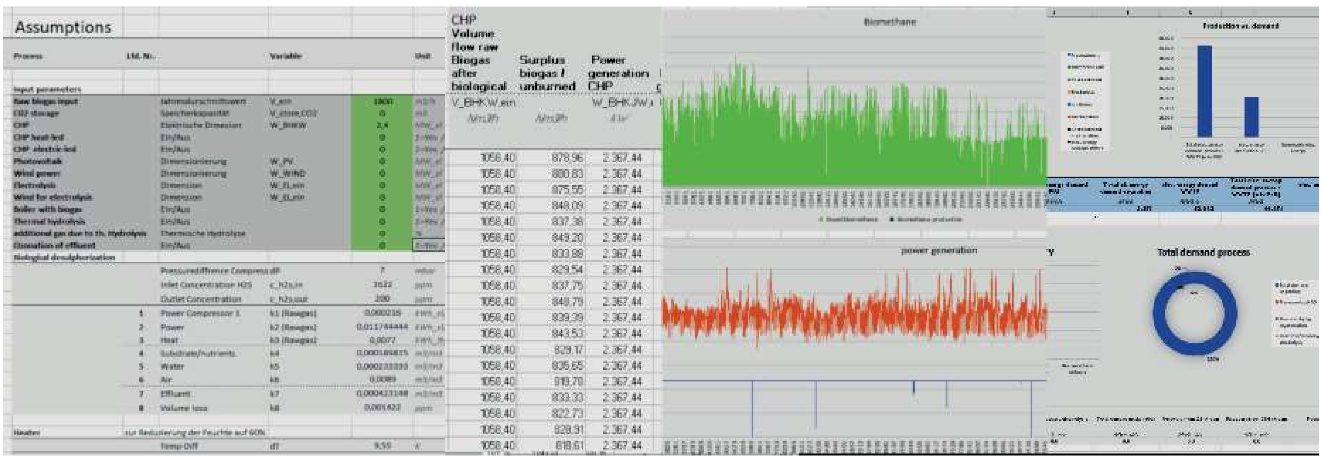
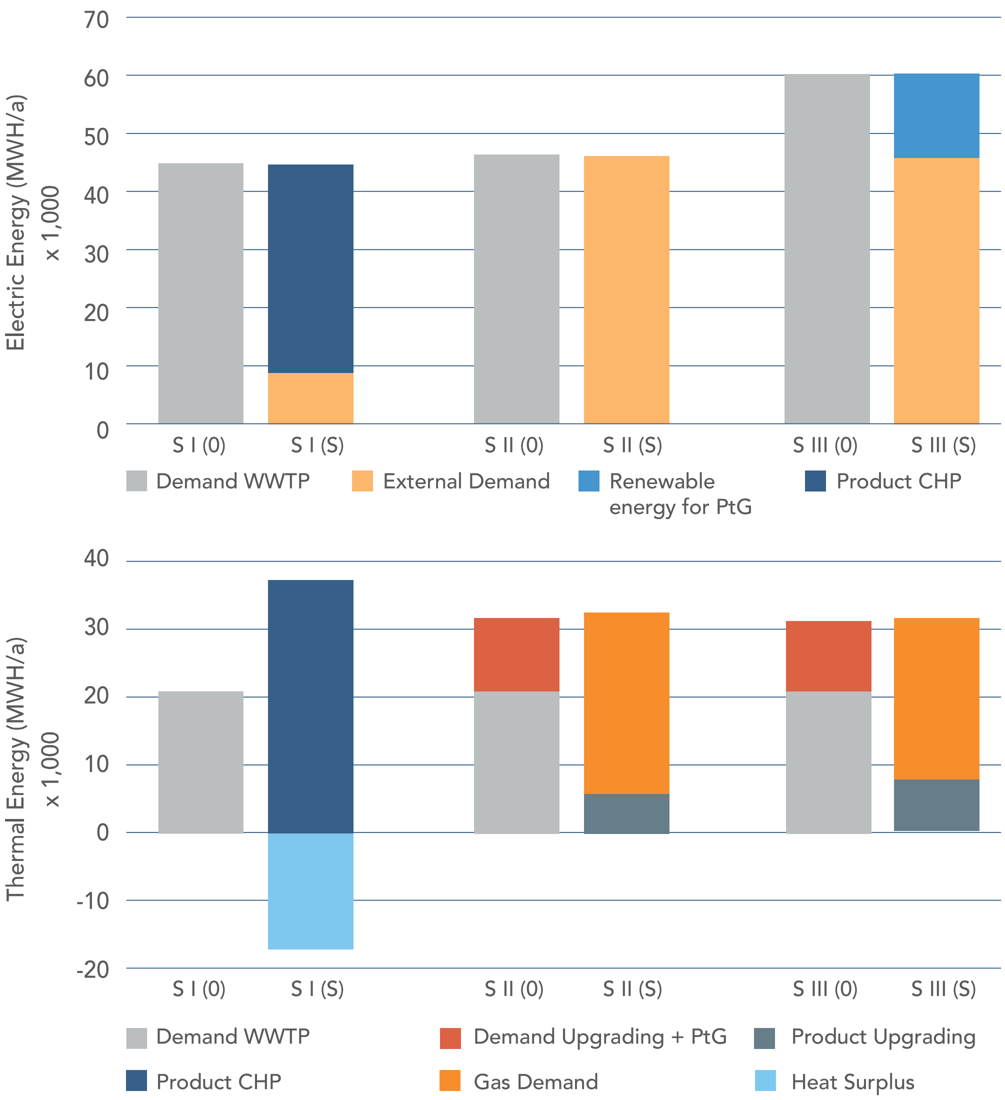


Figure 3.5 presents results regarding the electrical and thermal energy assessment by both demand and supply (internal or external). The comparison between demand and production of the three scenarios shows that the selected WWTP (SI) has 80% electrical self-efficiency, whereas for SII and SIII 100% of electricity has to be purchased externally from the grid to cover the total consumption.

Figure 3.5

Comparison of energy consumption (D), production and the external supply (S) of each scenario



Results given by the dynamic model regarding the thermal energy assessment are also presented in Figure 3.5. In scenario I, the WWTP produces excess heat of ≈ 15 GWh per year as waste heat due to a lack in external customers. Retrofitting the WWTP with technologies such as biogas upgrading or PtG in the future results in no excess heat. To close the overall heat balance between production and consumption at the WWTP, natural gas has to be purchased in amounts of ≈ 20 GWh per year for both those scenarios.

Ecological point of view

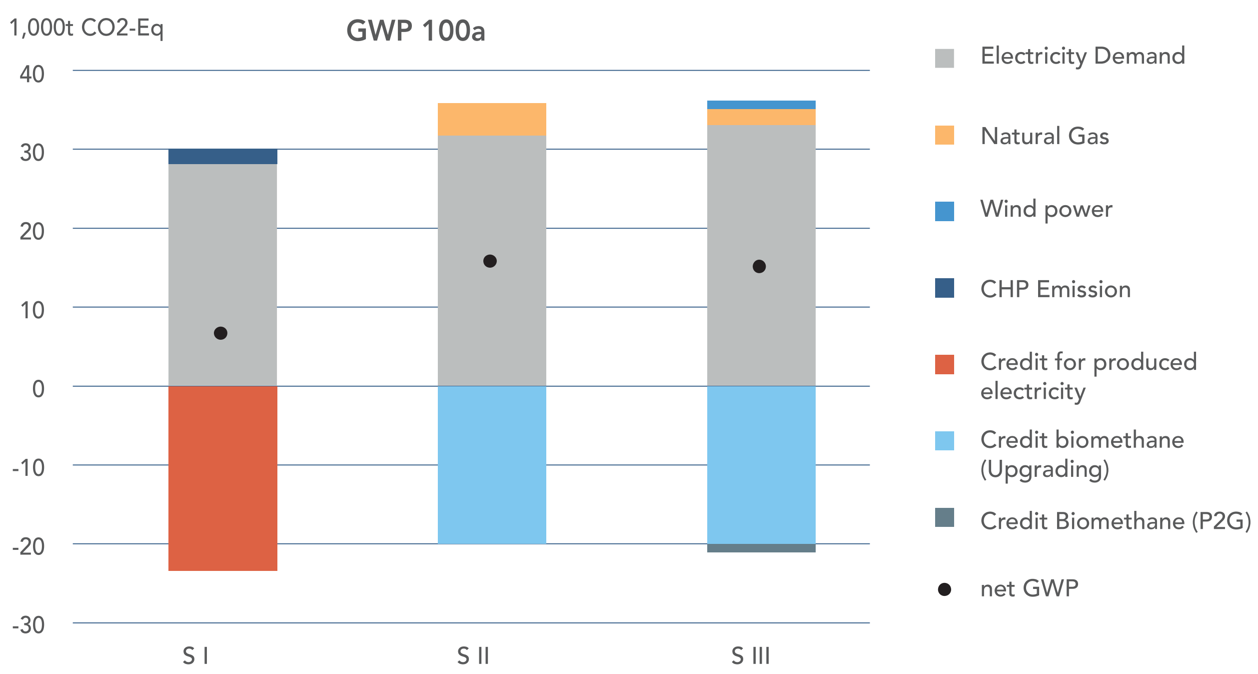
The environmental assessment analysis finally compares the global warming potential for a time horizon of 100 years (GWP100) of the three selected scenarios by using both the actual and also a future grid electricity mix. The function of the system is to utilize the biogas to generate secondary product like heat and electricity.

The functional unit is therefore the biogas amount produced in the year 2017 by the WWTP (16,079,808 m3). The model for the scenarios is created in the LCA software UMBERTO®.

Figure 3.6 shows that the net GWP100 is heavily influenced by the electrical consumption from the grid and its substitution depending on the used energy mix. Electricity generated by using biogas in the CHP unit is more beneficial in GWP than the biomethane credits generated from the same amount of biogas. Similarly, PtG is not worthwhile in environmental terms, also because biogas use for electricity production is more beneficial than substituting natural gas in the grid. The additional amount of produced biomethane on top of the upgraded biogas is quite small in the PtG scenario, indicating that the PtG unit is operating only 20 to 30% of the time and thus with low efficiency.

Figure 3.6

Comparison of global warming potential of each scenario



Economic point of view

For the economic assessment, data for CAPEX and OPEX calculations are based on cost data provided by suppliers. For cost of consumables (e.g.: electricity, natural gas, etc.), levies and subsidies, interests and inflation rates (empirical values) recommendations from operators as well as assumptions have been used (Stadtwerke Berlin, 2018).

Table 3.7 shows a summary of the key values for economic assessment.

Table 3.7

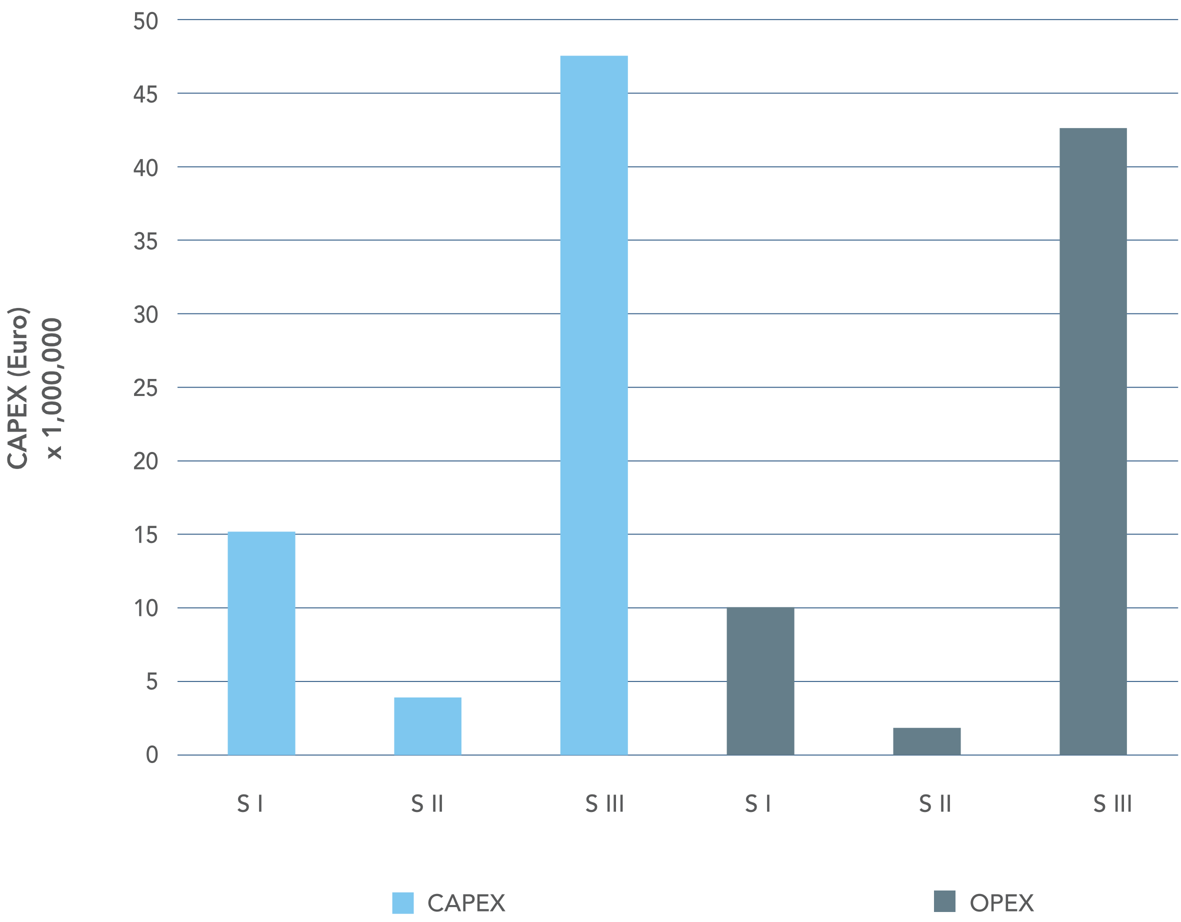
Summary of the key values for economic assessment of the different scenarios

Variables / Parameters	Value	Unit	Reference
Electricity price	199	€/MWh	(Stadtwerke Berlin, 2018)
Electricity for PtG	40	€/MWh	(Stadtwerke Berlin, 2018)
Natural gas	30	€/MWh	(Stadtwerke Berlin, 2018)
Biomethane (sell price) + avoided grid charge	55+7	€/MWh	(Stadtwerke Berlin, 2018)
Biomethane price increase	0.50	%/year	(Stadtwerke Berlin, 2018)
Water	1.80	€/m^3	(BWB, 2017)
Oxygen	0.12	€/m^3	Estimated

Figure 3.7 shows the results for CAPEX and OPEX of the different scenarios. Regarding the CAPEX it is apparent that a biogas upgrading plant (SII) is the least expensive option. It is even cheaper than investing in a CHP unit (SI). SIII has the highest investment cost, resulting from the very high cost for the methanation plant and especially the corresponding electrolyser, tripling the CAPEX compared to SI. The operational costs behave similarly to CAPEX in all the scenarios. As shown in the Figure 3.7, biogas upgrading (SII) is the cheapest option, followed by CHP unit (SI). The PtG process (SIII) has the highest operating costs.

Figure 3.7

Comparison of CAPEX and OPEX of different technologies



3.4.4 Conclusion

Recommendations from this study depend on where the focus is laid and which parameters are chosen. Considering the comprehensive energetic and economic analysis, scenario SII (upgrading of biogas and grid injection) is recommended as the most sustainable and future-proof option. From an ecological point of view, biogas upgrading will become more interesting in the future to contribute to climate policy. It remains to assess to which extent the biomethane production at the WWTP can contribute to the climate related goals and reduction of GHG emissions. If the focus is laid only on the GHG emissions, since explicit political commitments have been made in this field, the benefits of biogas upgrading will be realized only after a greener grid electricity mix is present.

It is observed that under current conditions, a combination of PtG technology with biogas upgrading in a WWTP offers no advantage over the scenarios without this technology. Currently, the lack of support scheme for PtG makes this concept uneconomical. For the moment, such a technology is reported to be not mature and too costly to be economically feasible. But its future role for the energy system is emphasized since other benchmark technologies to store energy have limited expansion capacity (i.e. pumped storage power). These statements coincide with results of this study and the created plant design.

In conclusion, it was shown that a biogas upgrading to produce biomethane using the presented technologies is a feasible option for the surveyed WWTP, especially in the near future under the assumed circumstances and parameters.