

Promoting rural Electrification in Sub-Saharan Africa: Least-Cost Modeling of decentralized Energy-Water-Food Systems

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Why?

600 Mio. capita

* 300 kWh/year/capita

* 0,4 USD/kWh

* 20 years

$$= 1,4 * 10^{12} \text{ USD}$$

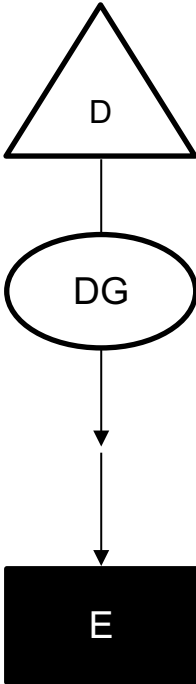
Case Study: St. Rupert Mayer, Zimbabwe



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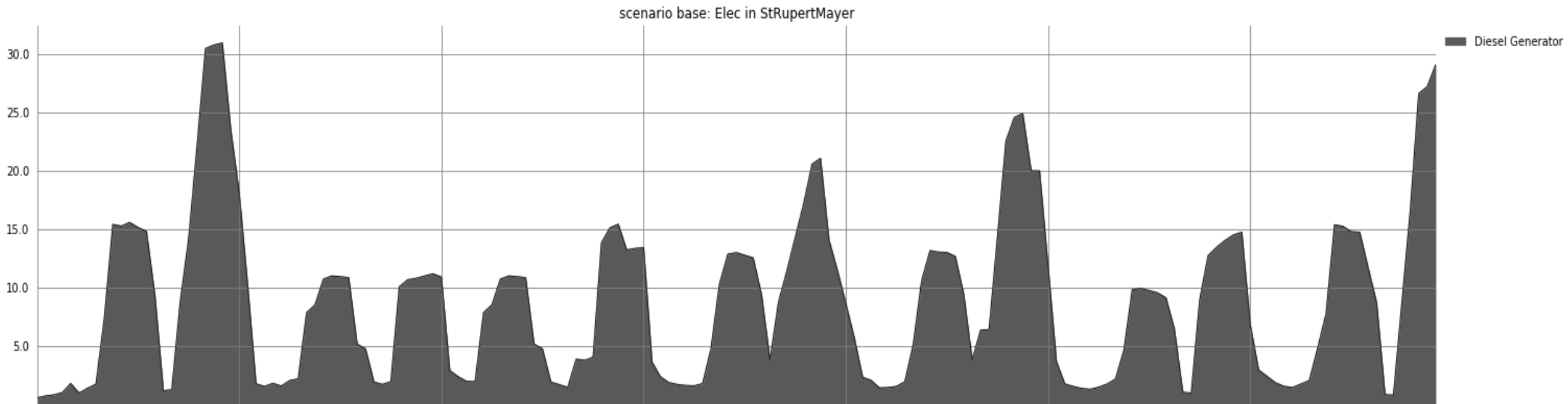
- Village in rural Zimbabwe
- 250 inhabitants
- Model input data by **literature, local measurements and questionnaires**
- No (reliable) power grid connection
- Electrical load profile based on questionnaire (Monte Carlo)
- No water grid connection
- Sufficient groundwater
- Good soils (max 10 ha)
- **750 USD annual salary for farmers** (= variable costs field)
- Weighted average costs of capital (**WACC**): **15% per year**

Scenario 1: Diesel

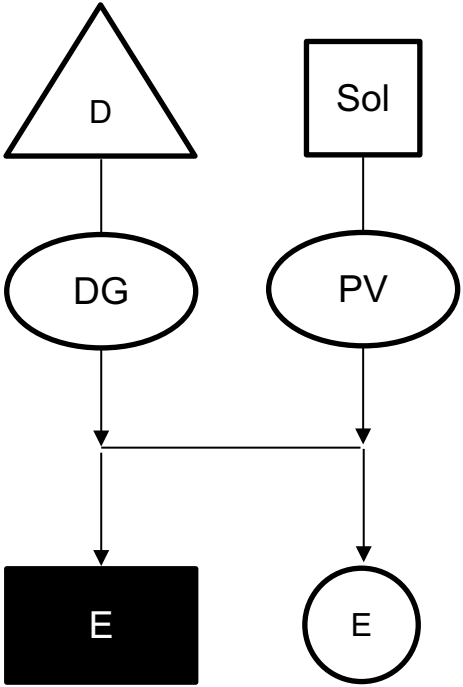


Scenario 1: Diesel - Electricity Supply [kW]

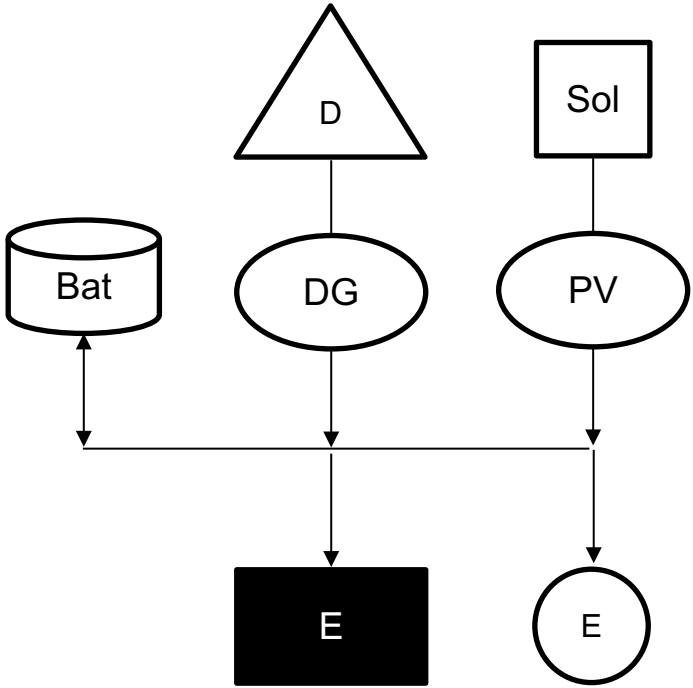
- LCOE: 44,5 c/kWh
- Annual Costs per Capita: 153,3 USD/year



Scenario 2: + PV

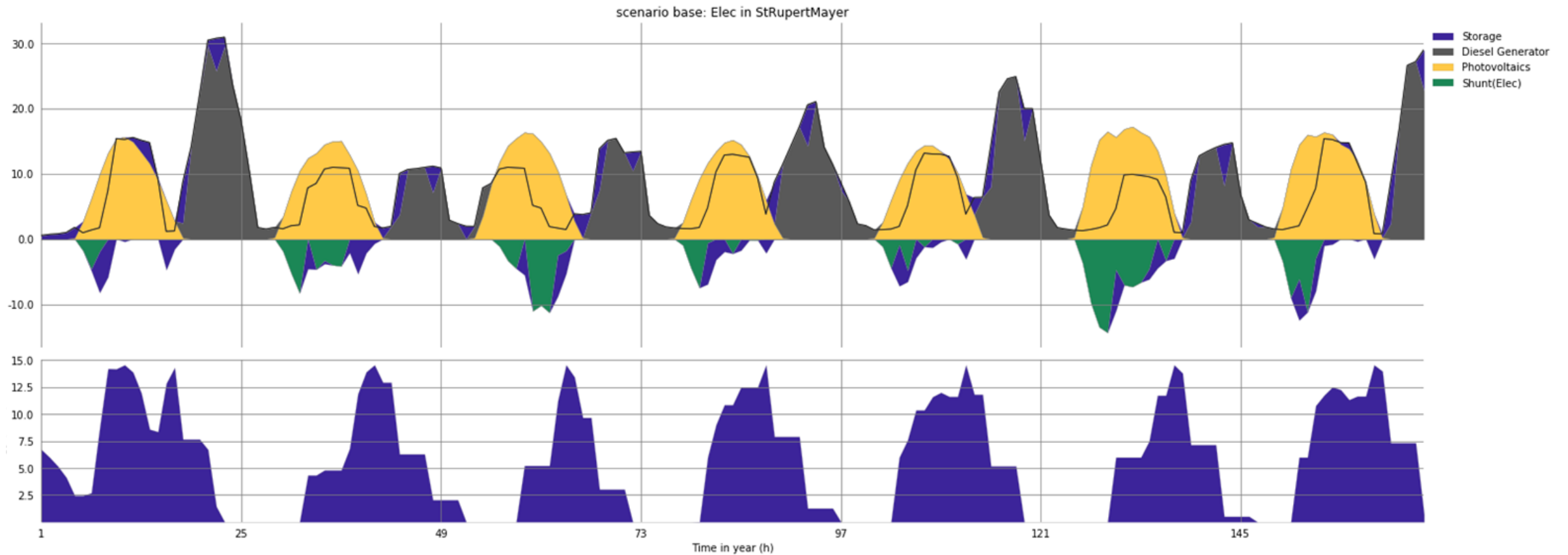


Scenario 3: + Batteries

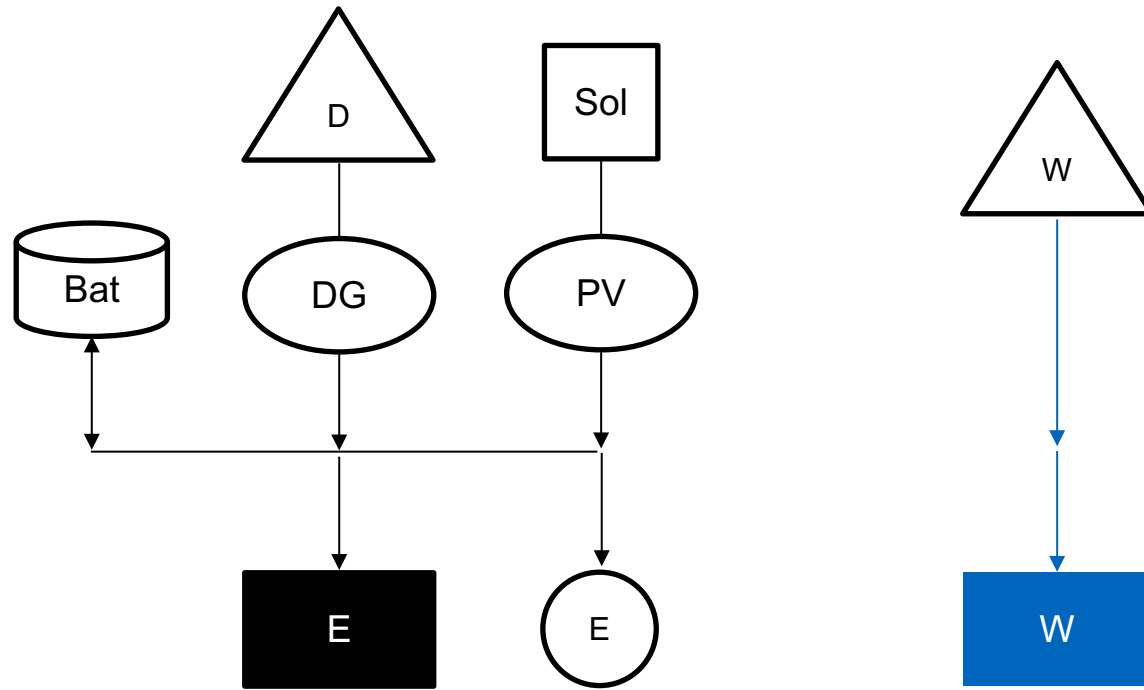


Scenario 3: + Batteries - Electricity Supply [kW]

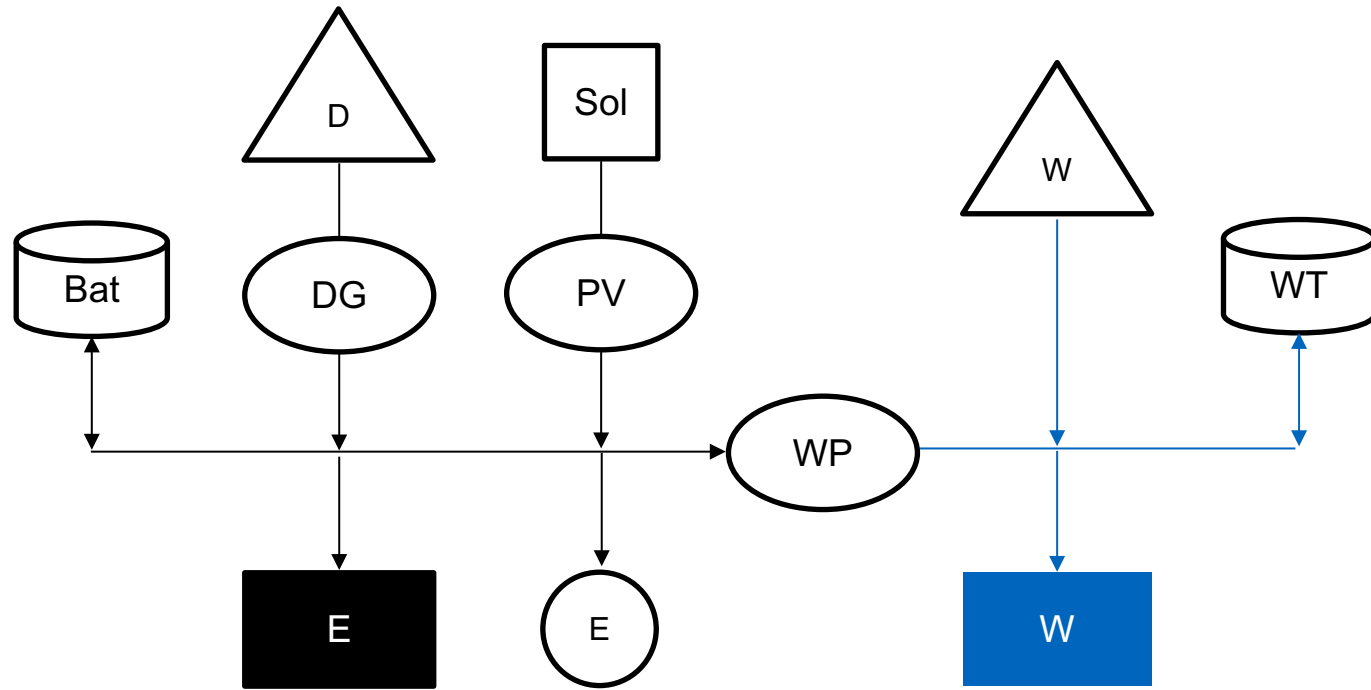
- LCOE: 37,9 c/kWh (before: 44,5 c/kWh)
- Annual Costs per Capita: 130,8 USD/year (before: 153,3 USD/year)



Scenario 4: + Water Demand

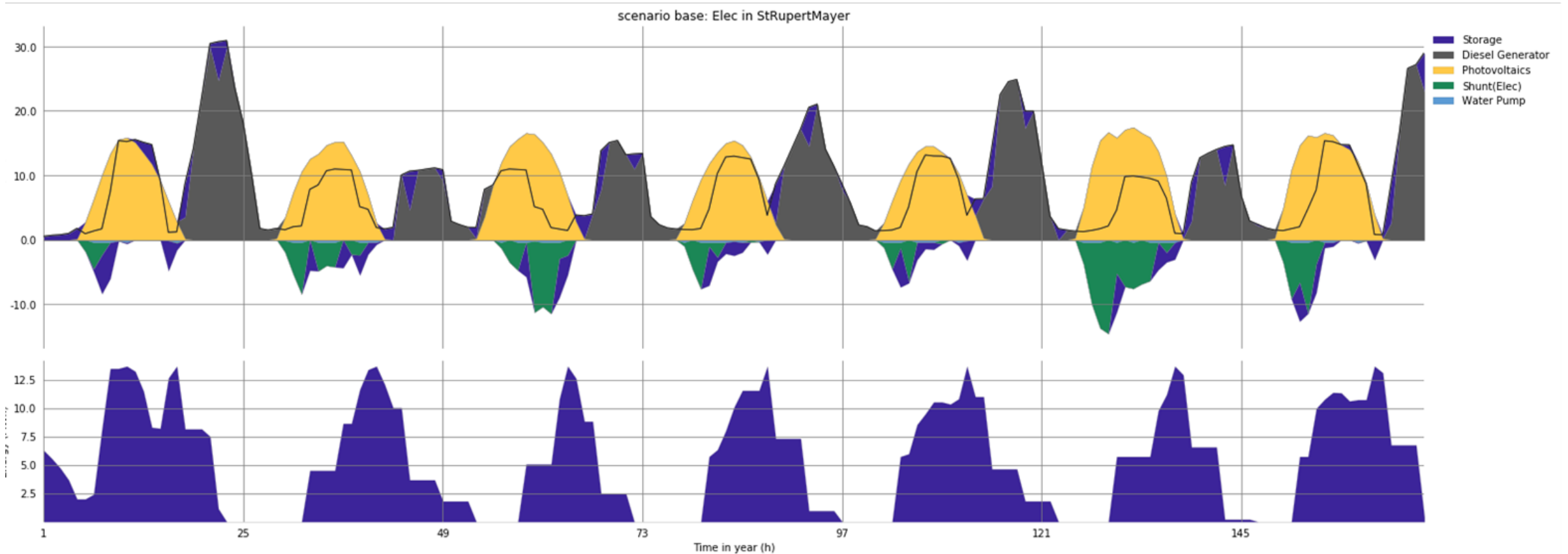


Scenario 5: + Water Pump

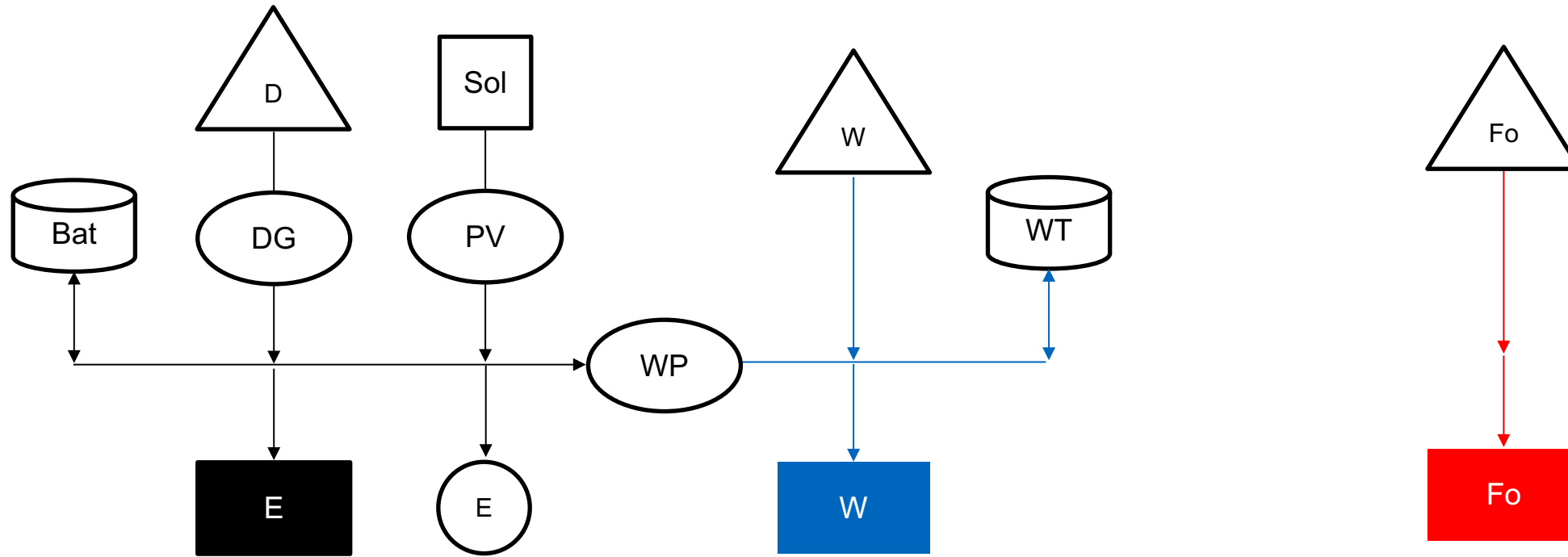


Scenario 5: + Water Pump - Electricity Supply [kW]

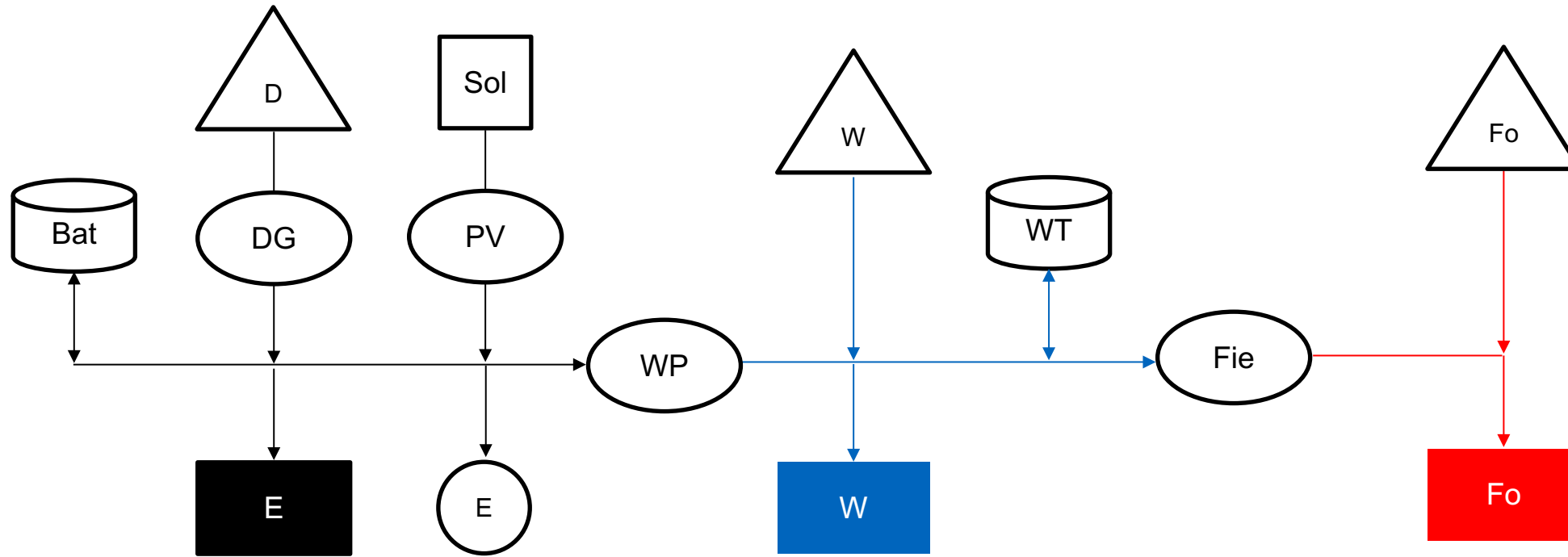
- LCOE: 37,7 c/kWh (before: 37,9 c/kWh)
- Annual Costs per Capita: 132,0 USD/year (before: 130,8 USD/year)



Scenario 6: + Food Demand



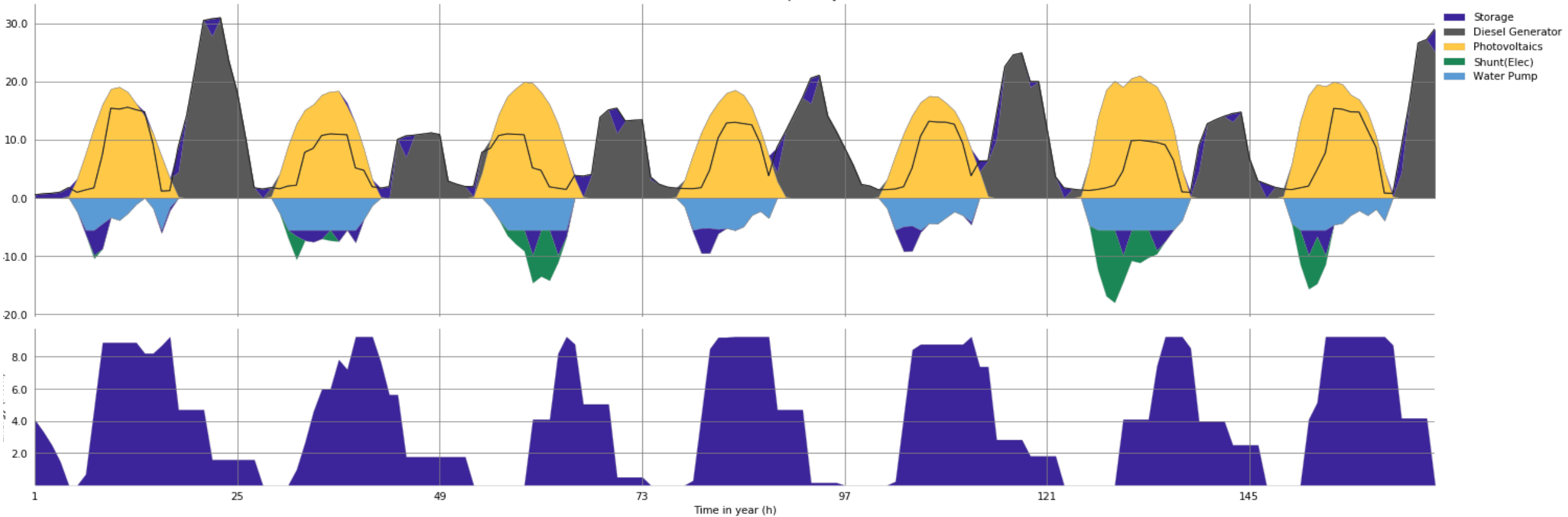
Scenario 7: + Fields



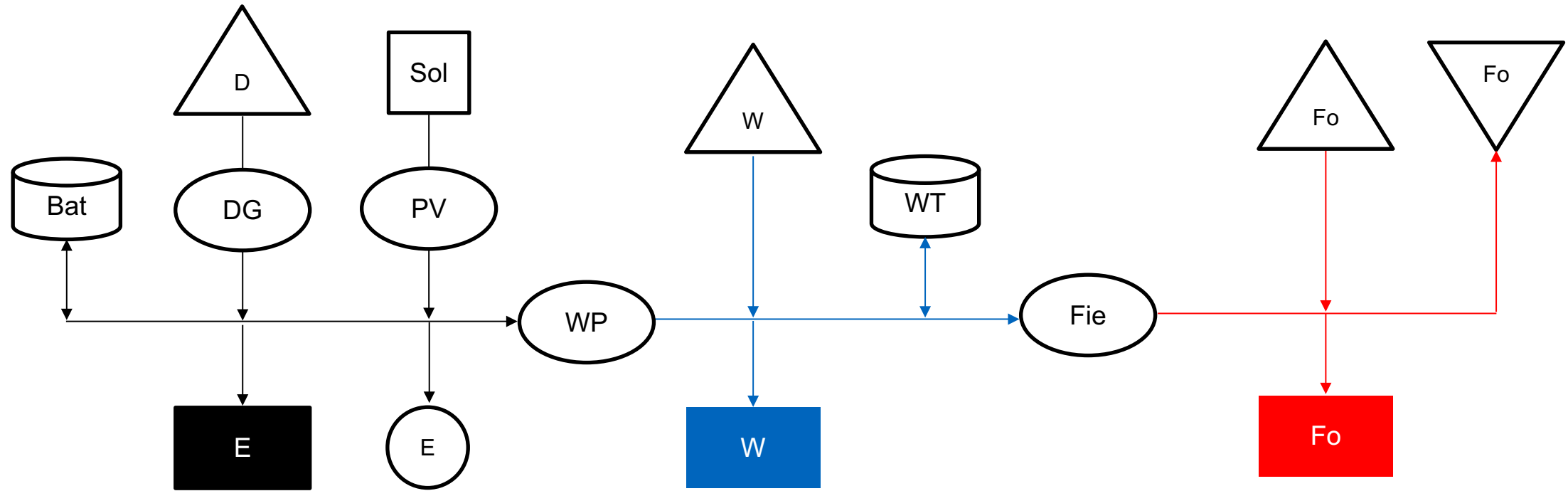
Scenario 7: + Fields - Electricity Supply [kW]

- LCOE: 34,4 c/kWh (before: 37,7 c/kWh)
- Annual Costs per Capita: 189,8 USD/year (before: 132,0 USD/year)
- Field Size: 2,9 ha
- Jobs created: 17

scenario base: Elec in StRupertMayer



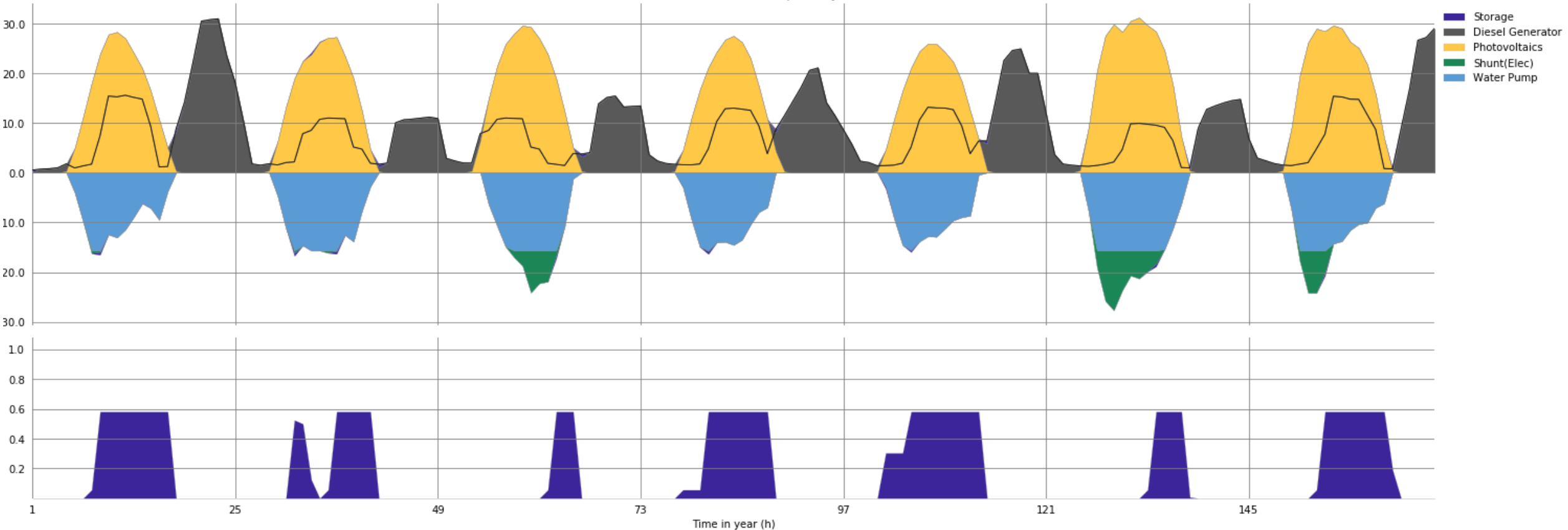
Scenario 8: + Food Selling



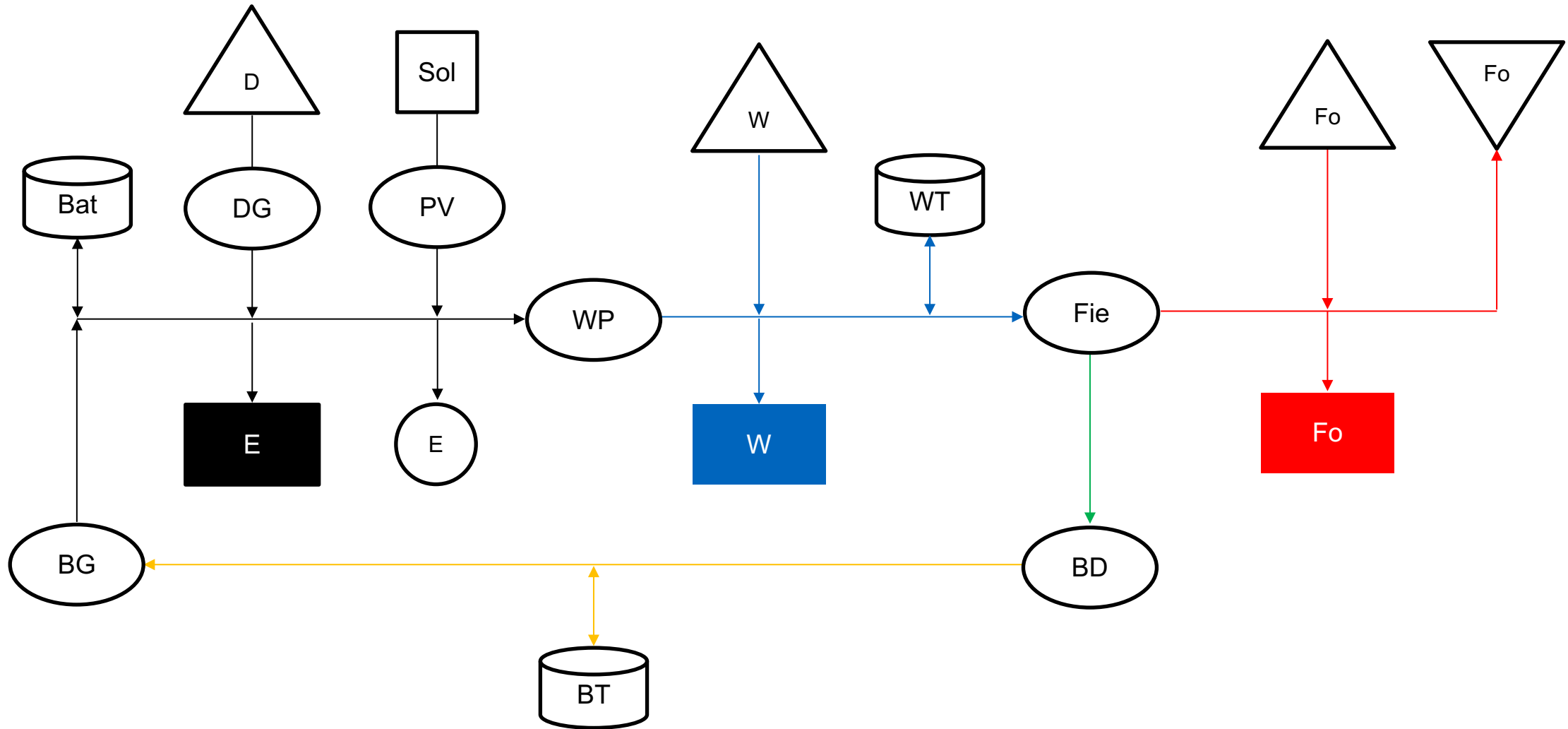
Scenario 8: + Food Selling - Electricity Supply [kW]

- LCOE: 30,5 c/kWh (before: 34,4 c/kWh)
- Annual Costs per Capita: 105,0 USD/year (before: 189,8 USD/year)
- Field Size: 10 ha (= max) (before: 2,9 ha)
- Jobs created: 60 (before: 17)

scenario base: Elec in StRupertMayer

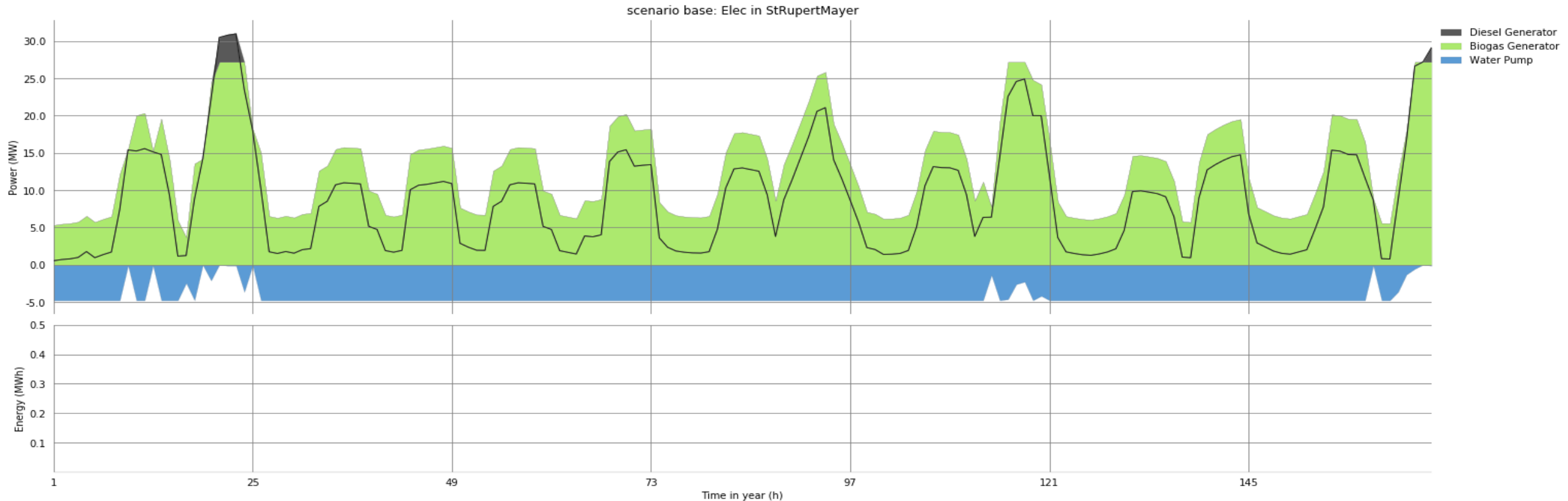


Scenario 9: + Biogas



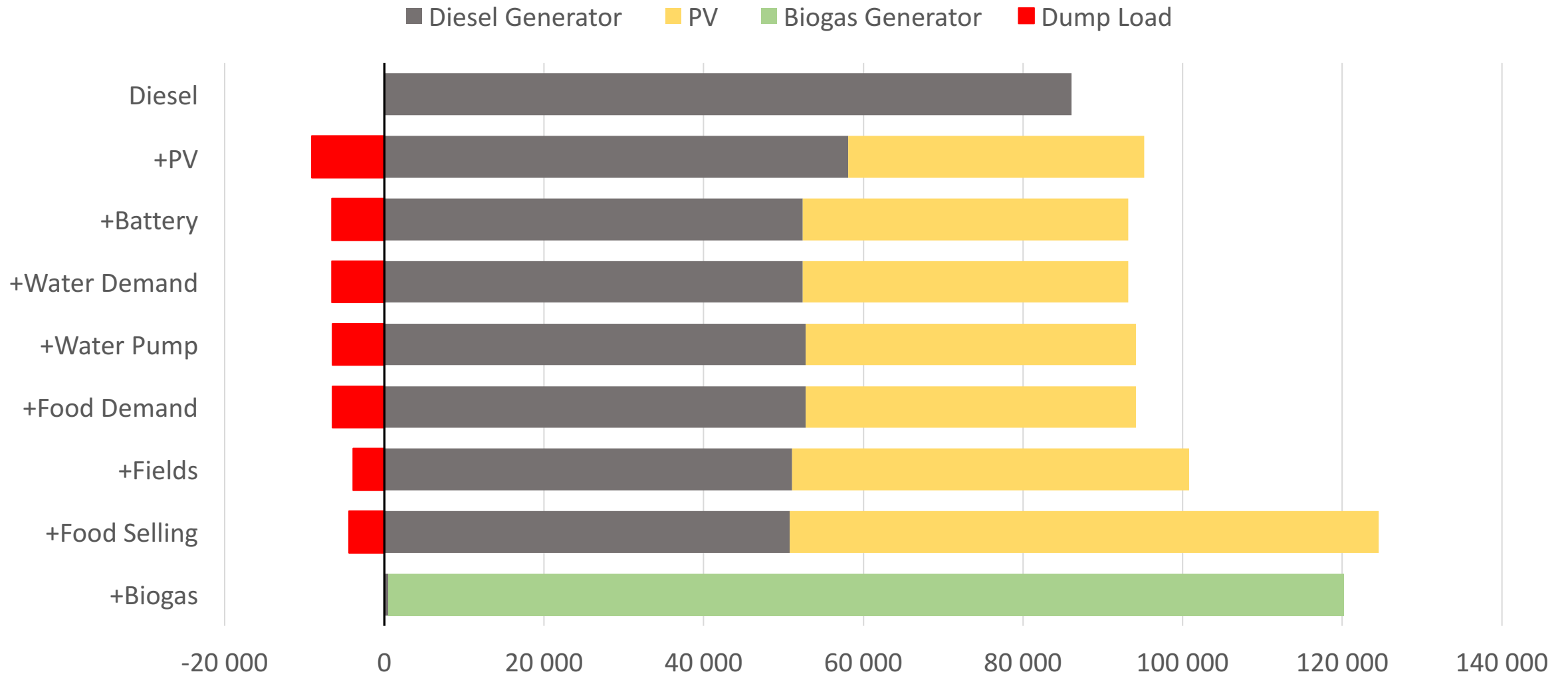
Scenario 9: + Biogas - Electricity Supply [kW]

- LCOE: 16,4 c/kWh (before: 30,5 c/kWh)
- Annual Costs per Capita: 28,6 USD/year (before: 105,0 USD/year)
- Field Size: 10 ha (= max) (before: 10 ha)
- Jobs created: 60 (before: 60)

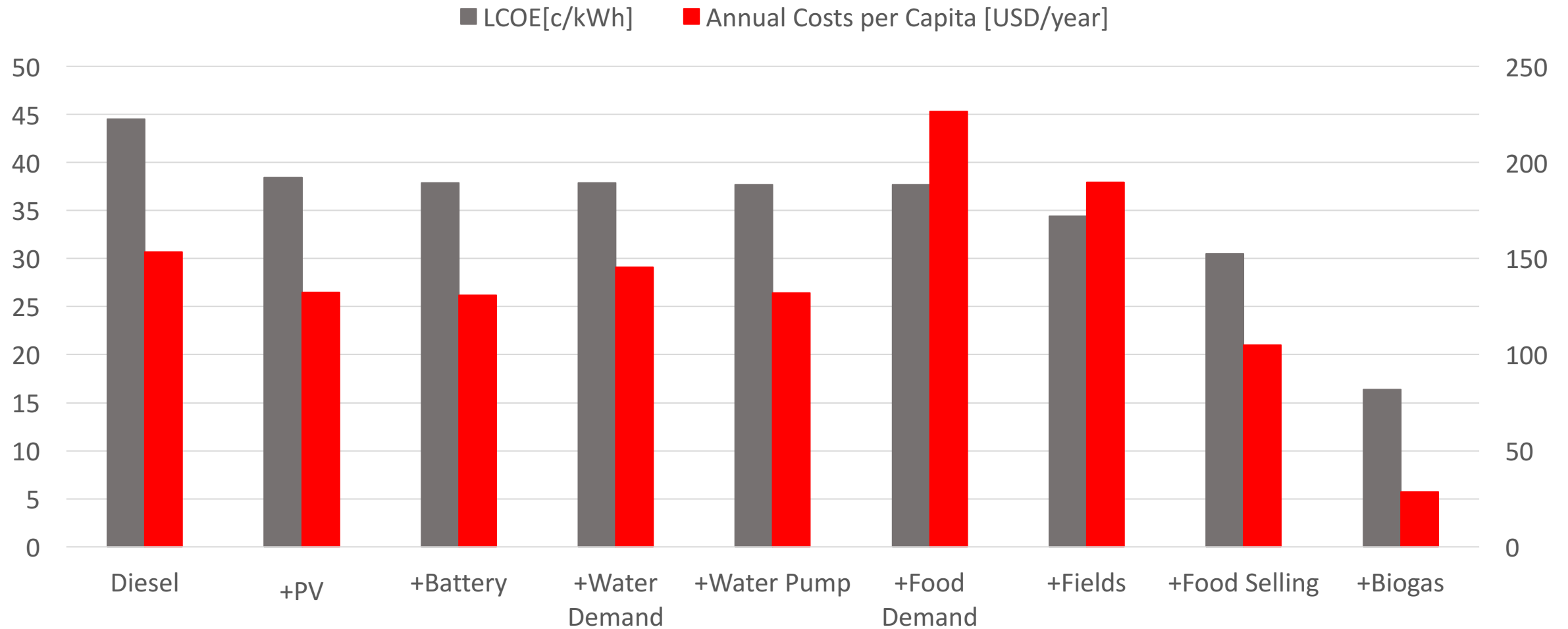


Summary

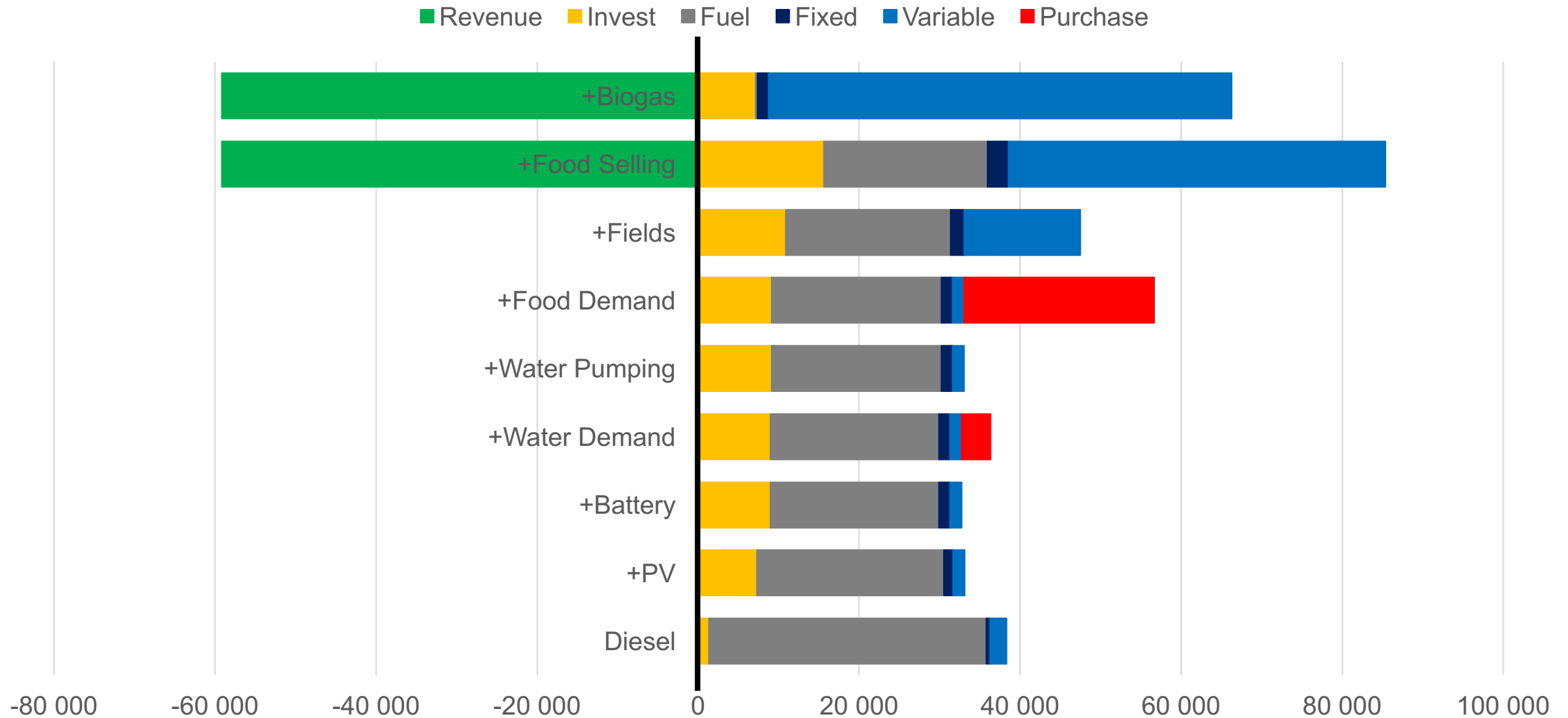
Summary – Annual Energy Generation [kWh]

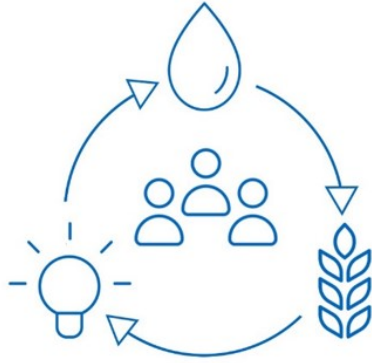


Summary – LCOE & Annual Costs per Capita



Summary – System Costs [USD/year]





TU eMpower Africa

Decentralized Energy-Water-Food Solutions for Sustainable Development















Thanks for your attention!!!

Next Steps

- Rainfall timeseries
- Ground water as storage
- Enhanced soil analysis
- Fertilizer demand
- Fertilizer: Commercial vs. biogas digester residue
- Life-Cycle-Analysis for soil nutrients
- Different crops
- Variation crop prices
- Livestock farming
- Food processing
- Other commercial and social power loads
- Cooking: Biogas vs. firewood
- Labor as commodity
- Intertemporal modelling

Legend (1)

	Electricity		Demand(t)		Process
	Water		Suplm(t)		Storage
	Bio-Waste		Sell(t)		Shunt (Dump Load)
	Biogas		Buy(t)		
	Food				

Legend (2)

Bat	Battery	PV	Photovoltaic
BD	Biogas Digester	Sol	Solar Radiation
BG	Biogas Generator	M	Maize
BS	Biogas Storage	MF	Maize Field
D	Diesel	W	Water
DG	Diesel Generator	WP	Water Pump
E	Electricity	WT	Water Tank