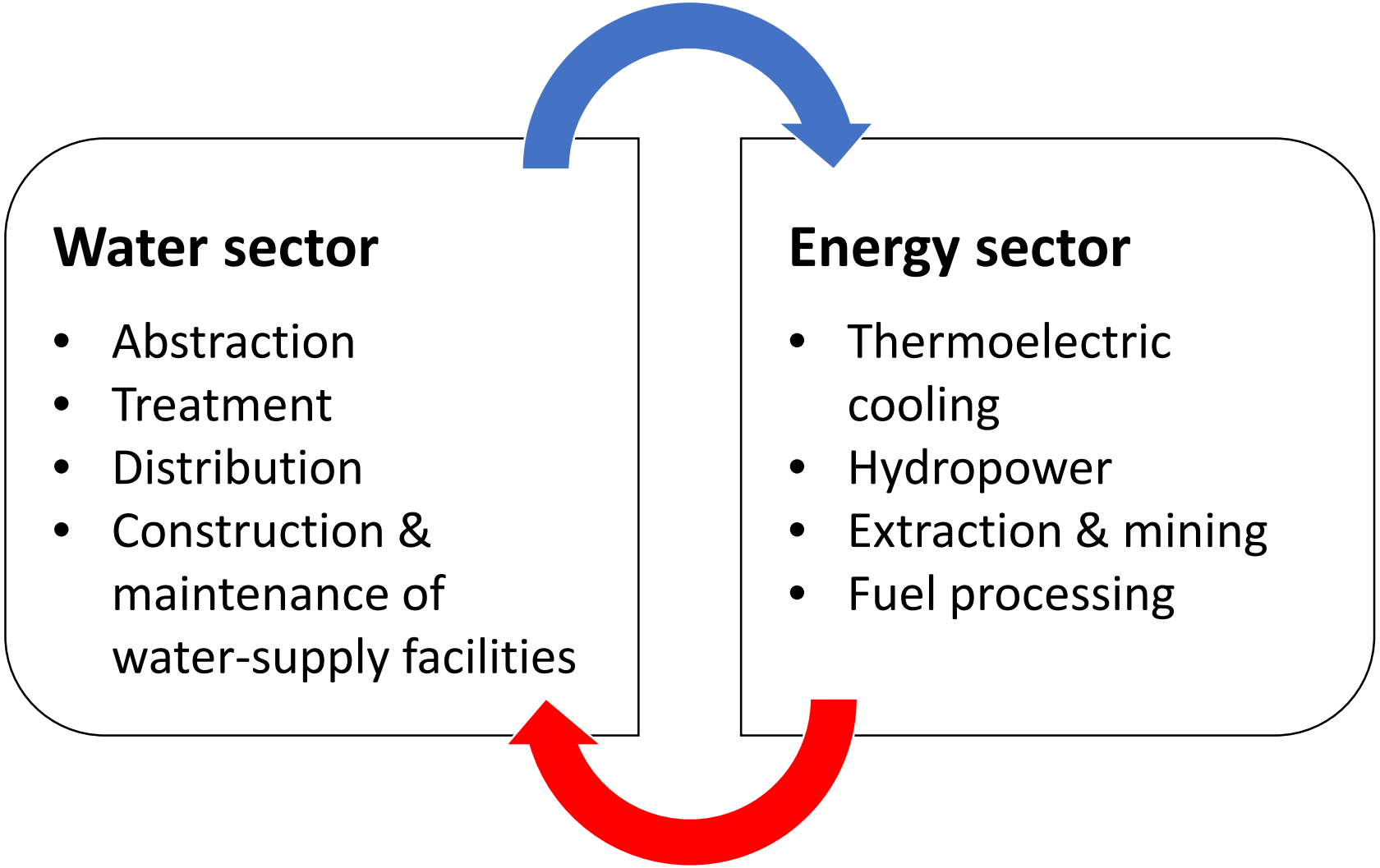
CENTRE FOR RENEWABLE & SUSTAINABLE ENERGY STUDIES

INDUSTRIAL ENGINEERING
Stellenbosch University

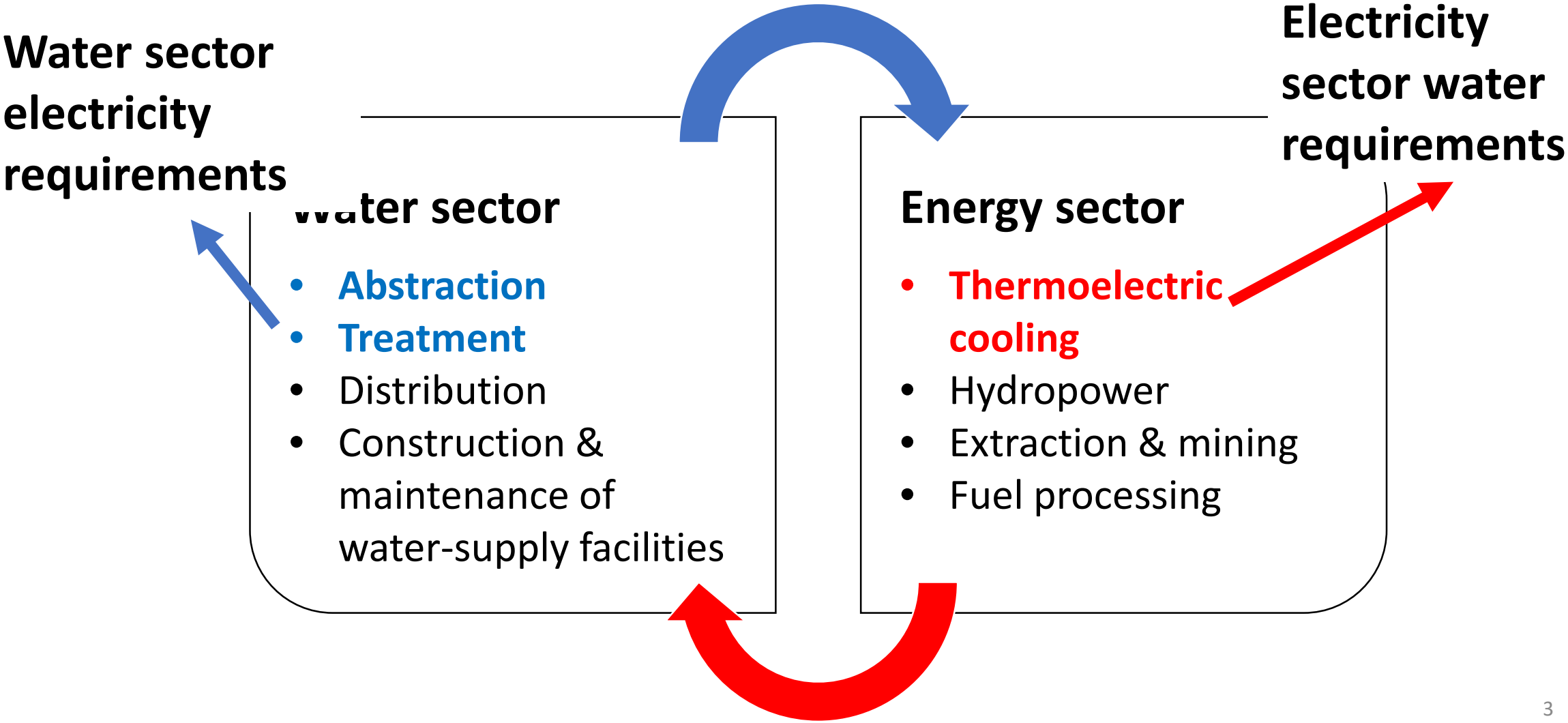
Sustainability assessment of technology systems that address the energy-water nexus; with specific emphasis on desalination

Liesel Swart Alan C Brent Josephine K Musango

The Energy-Water Nexus



The Energy-Water Nexus



Western Cape Context

Water restrictions

Water crisis

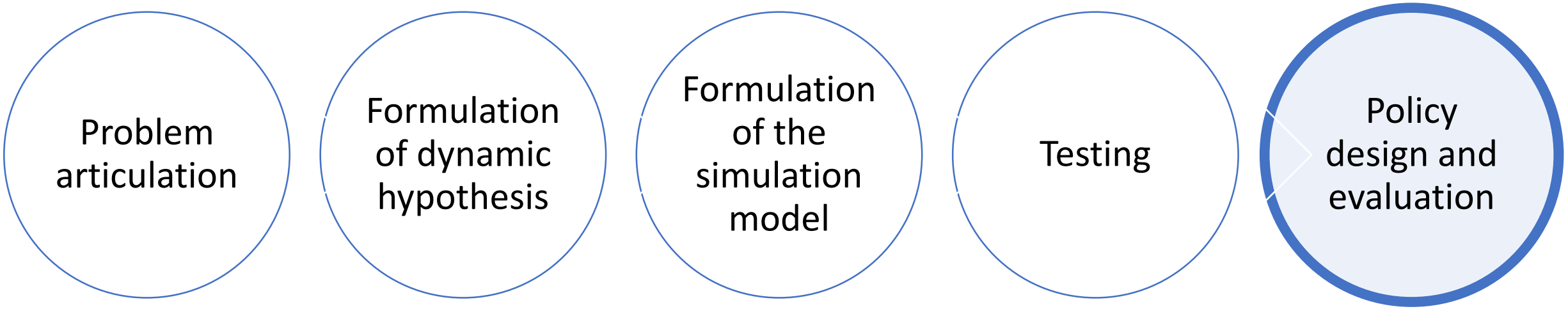
Loadshedding

Desalination

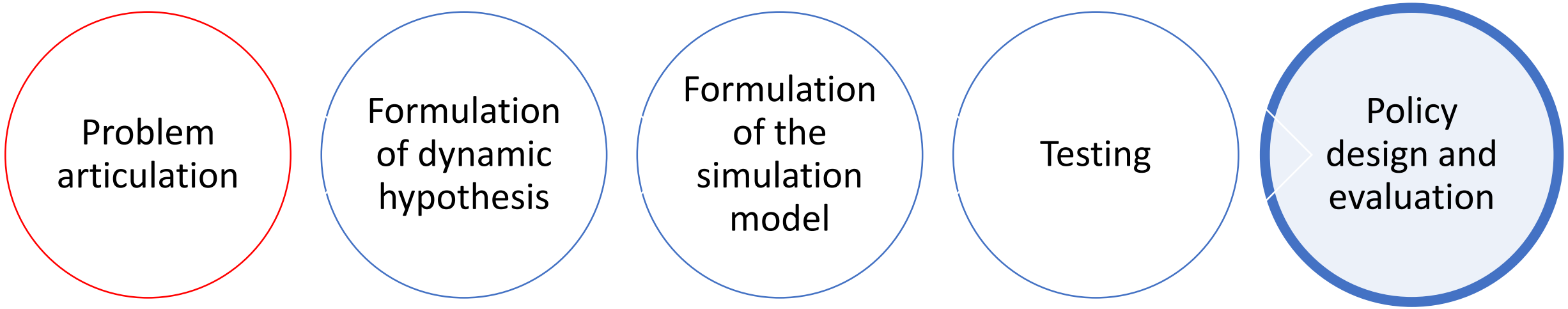
Climate change

Imported electricity

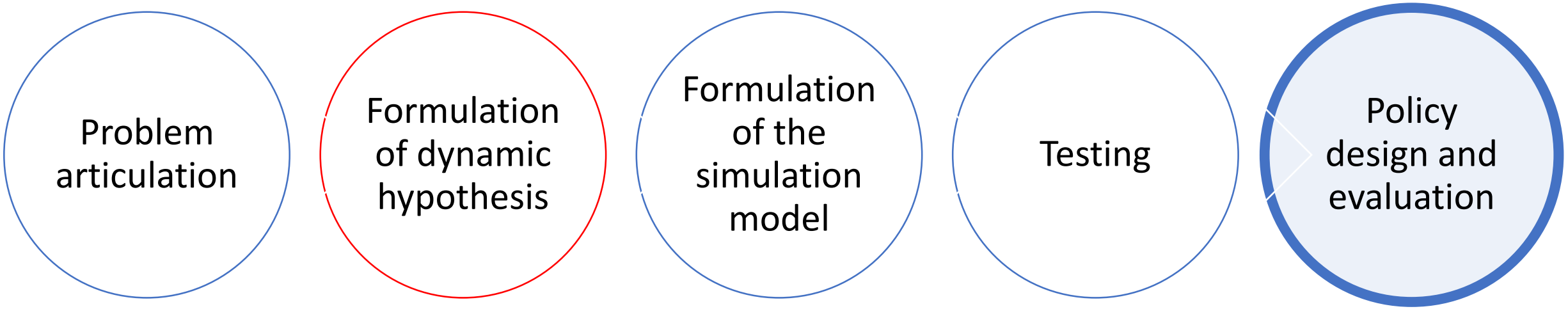
Methodology: A System Dynamics Approach



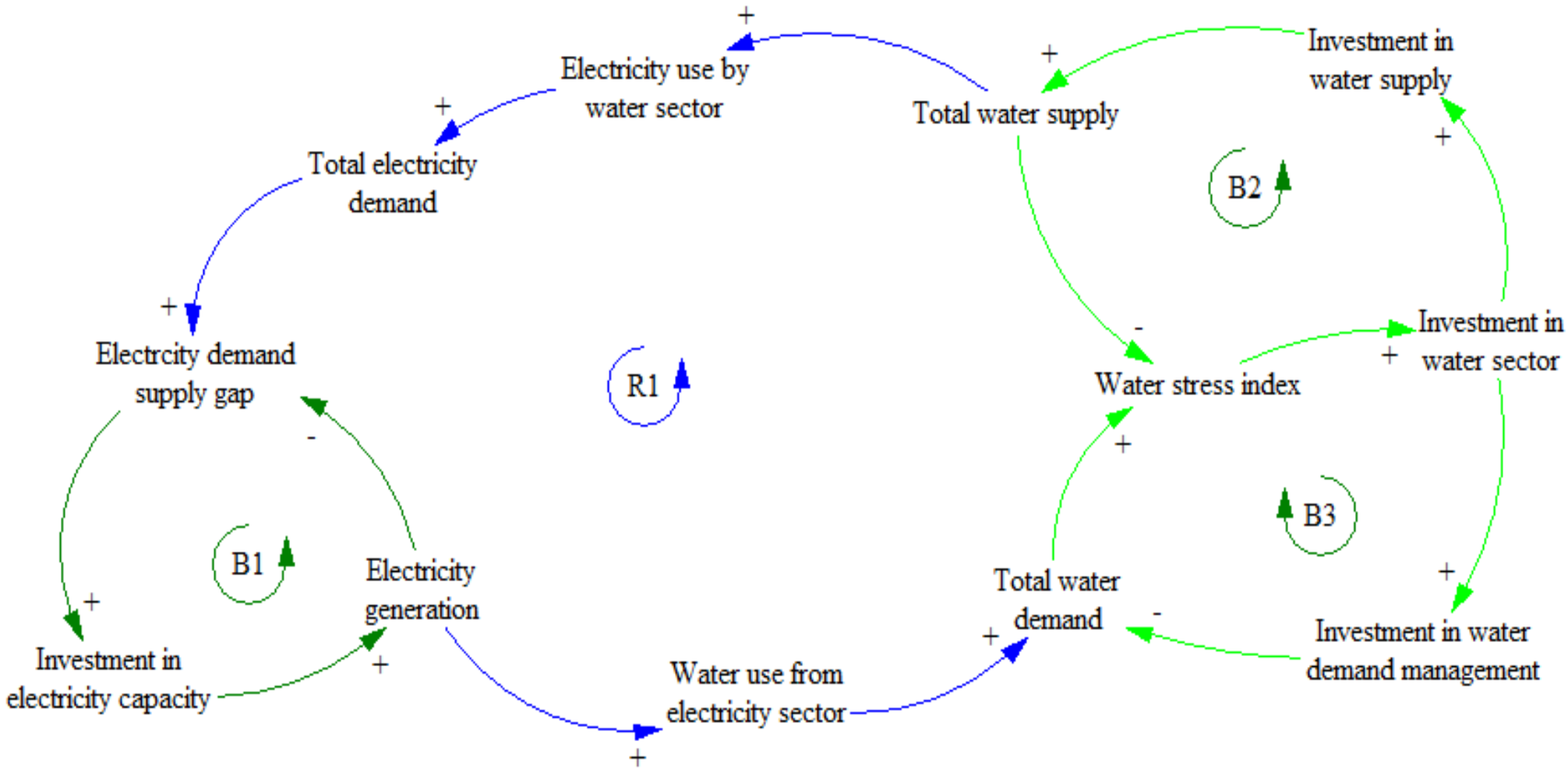
Methodology: A System Dynamics Approach



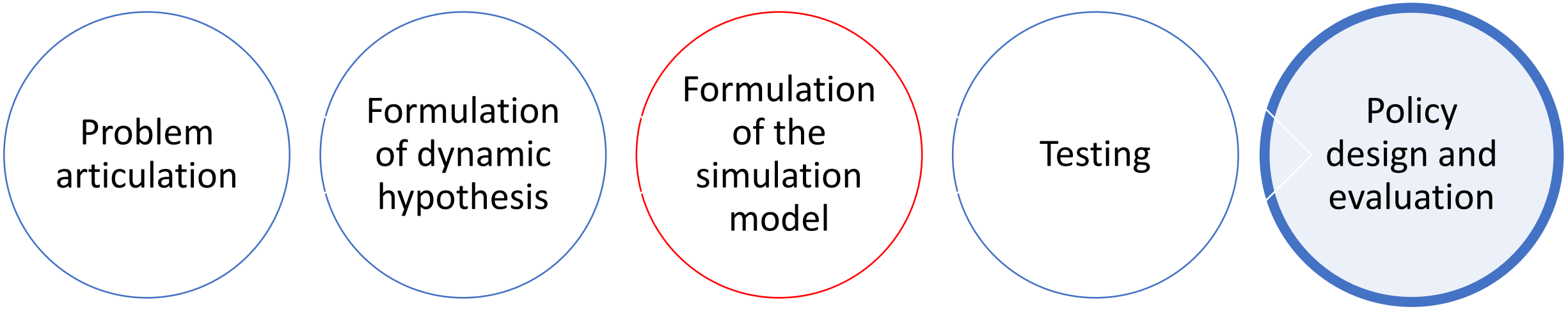
Methodology: A System Dynamics Approach



Conceptual Model



Methodology: A System Dynamics Approach



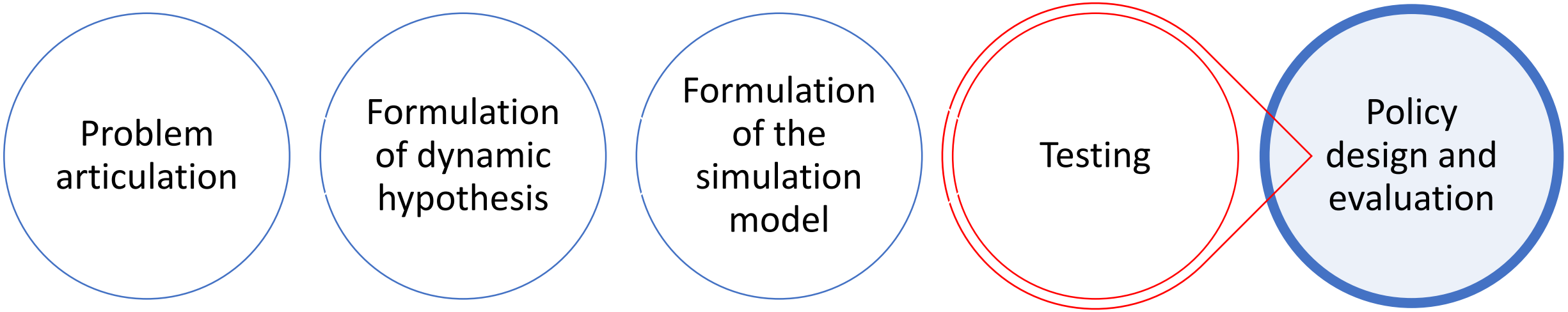
Dynamic Model: Water Sector

Water supply sub-models	Water supply & demand sub-model	Water sector investments sub-model	Water sector electricity use sub-model
• Surface water supply • Groundwater supply • Waste water treatment supply • Desalination supply	• Total water demand • Total water supply • Water stress index	• Investment in water demand management • Decrease in per capita water demand • Investment in water supply • Increase in water supply capacity	• Electricity consumption for all sources of supply • Total water sector electricity consumption

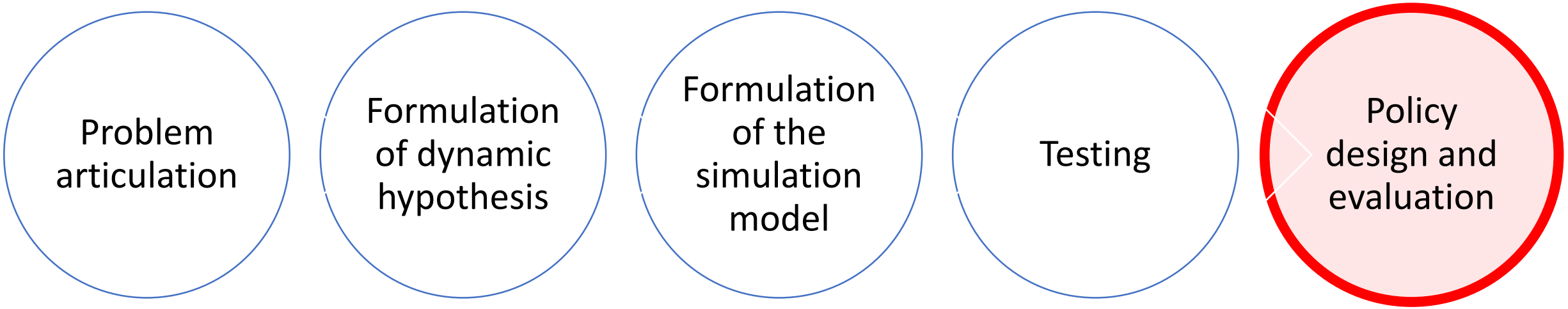
Dynamic Model: Electricity Sector

Electricity supply sub-models	Electricity demand & technology share sub-models	Electricity sector investments sub-model	Electricity sector water use sub-model
• Nuclear electricity supply • Gas power electricity supply • Pumped storage electricity supply • Solar PV electricity supply • Wind electricity supply	• Total electricity demand • Total electricity supply • Demand & supply gap • Electricity generation share of each technology	• Investment allocations to electricity generation technologies • New electricity generation capacity	• Water consumption for all sources of supply • Total electricity sector water consumption

Methodology: A System Dynamics Approach



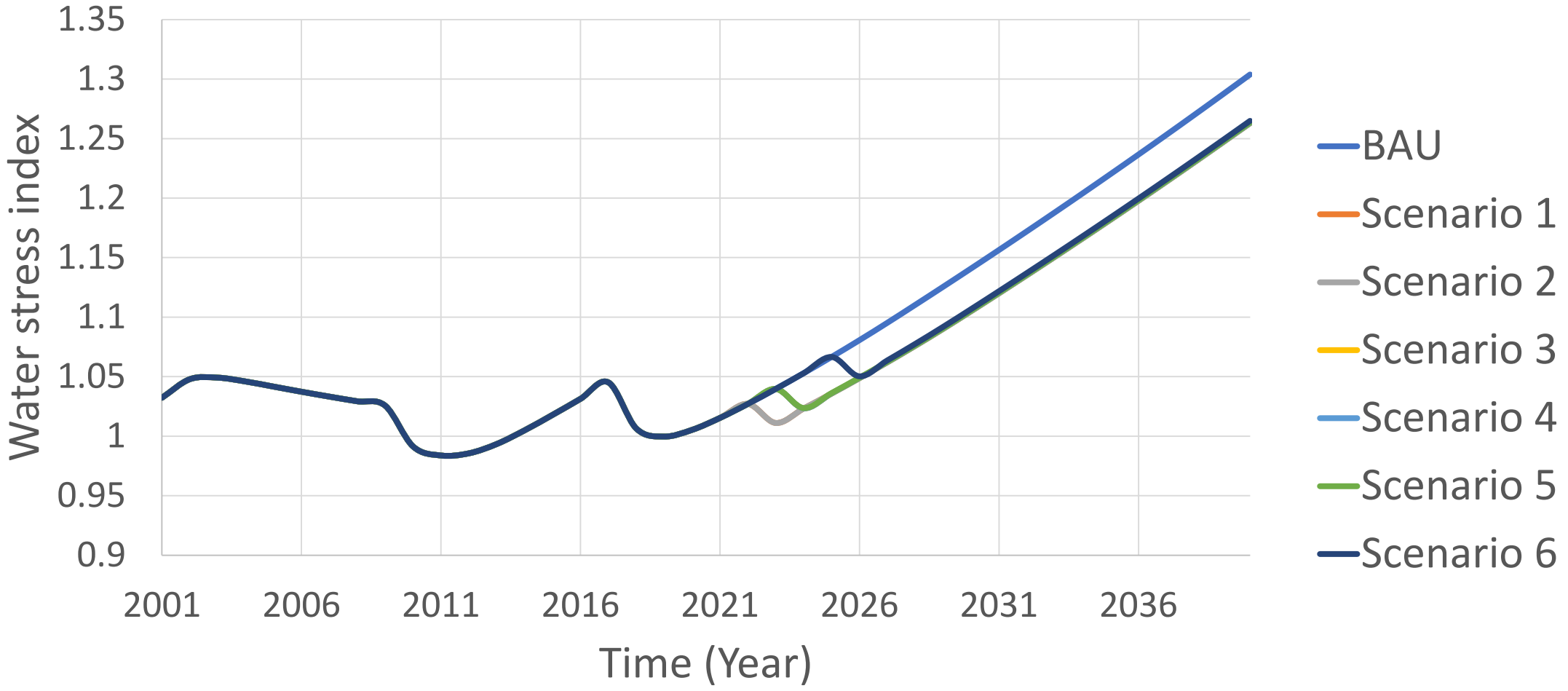
Methodology: A System Dynamics Approach



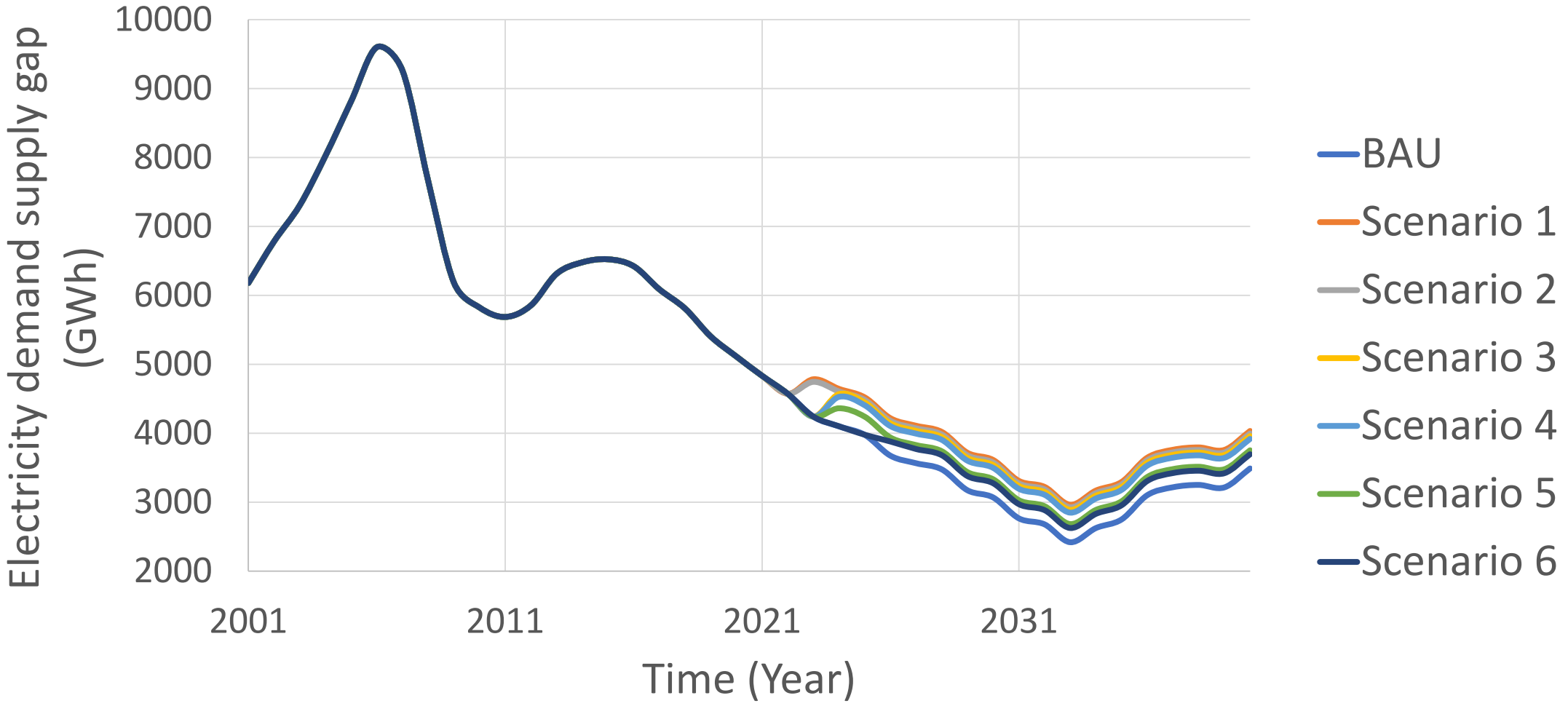
Scenarios

Scenario	Investment in water supply	Desalination technology type	Thermal energy from waste heat	Solar energy	Required investment (million R)
BAU	No	-	-	-	-
1	Yes	MED	No	None	3 811
2	Yes	MED	Yes	None	3 816
3	Yes	MED	No	FPC	4 012
4	Yes	MED	Yes	FPC	4 017
5	Yes	RO	No	None	4 468
6	Yes	RO	No	PV	6 213

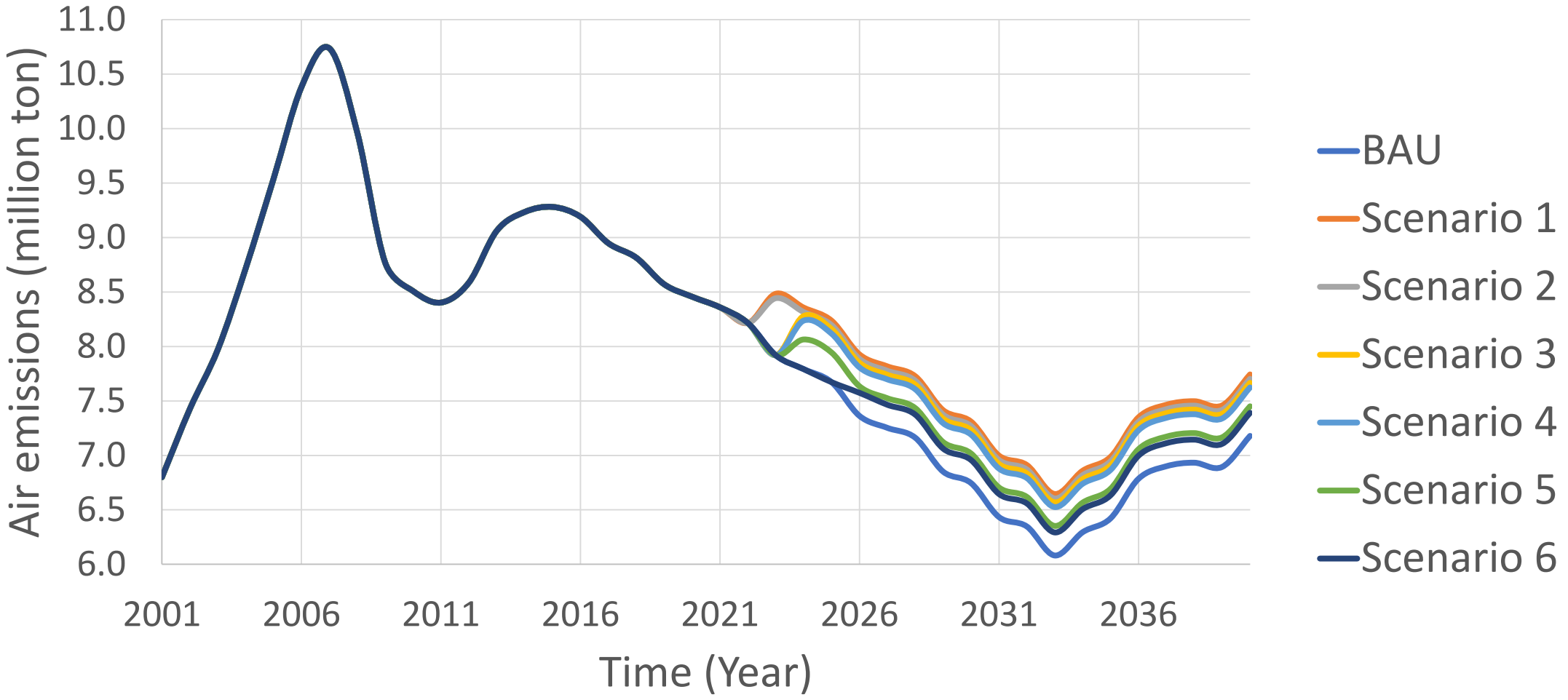
Water Stress Index



Electricity demand supply gap

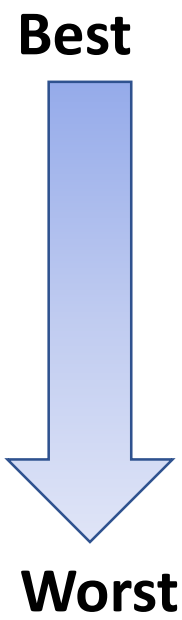


Air Emissions from Electricity Generation



Conclusions

Capital cost	Electricity demand supply gap	Air emissions from electricity generation
1	6	6
2	5	5
3	4	4
4	3	3
5	2	2
6	1	1



Recommendations

Matters that require further investigation:

- Running costs
- Brine disposal
- Saldanha Bay’s environmental regulations
- Alternative interventions

CENTRE FOR RENEWABLE & SUSTAINABLE ENERGY STUDIES

INDUSTRIAL ENGINEERING
Stellenbosch University

THANK YOU