Handling future uncertainties in urban drainage planning using flexible systems

The COFAS method

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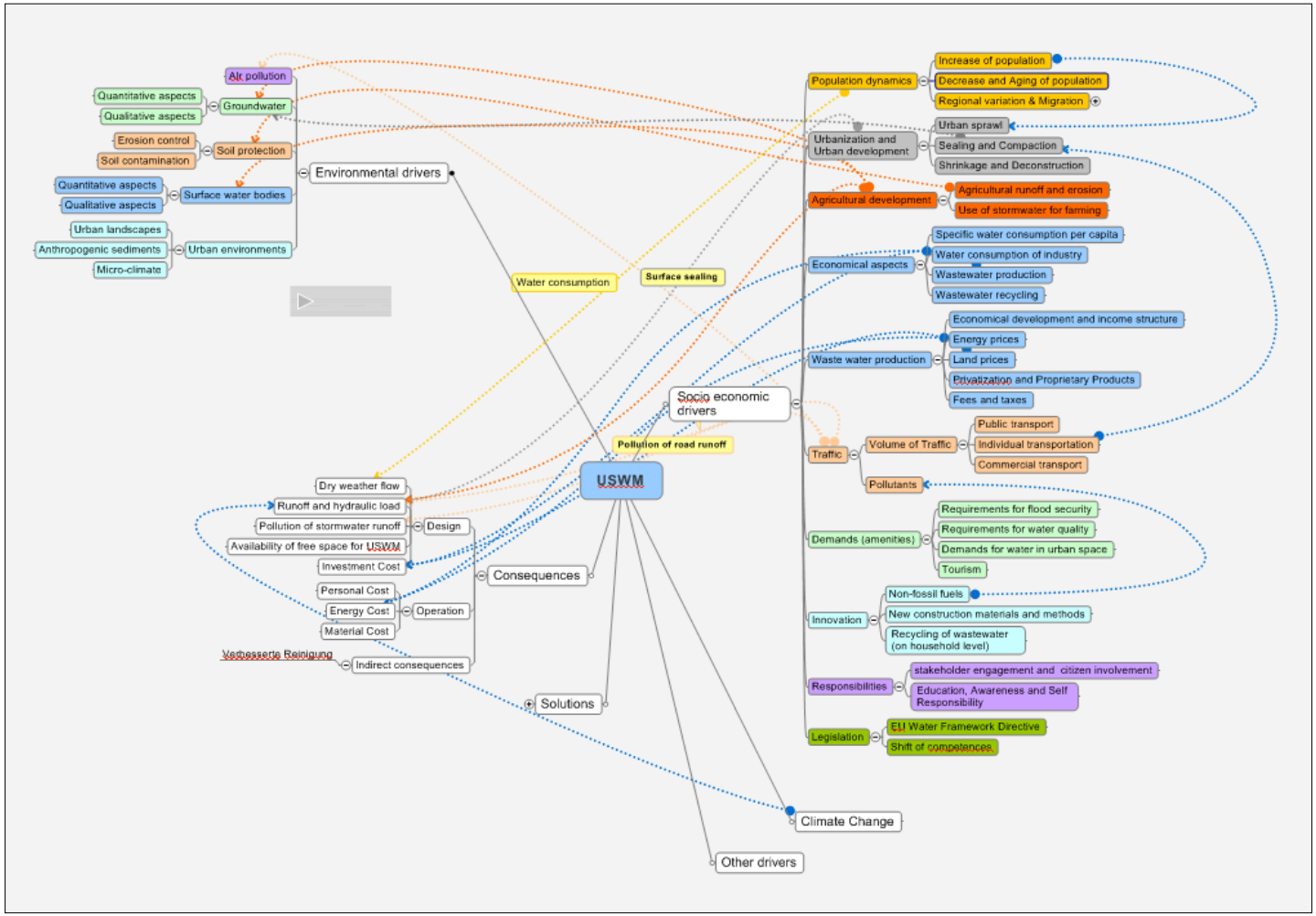
Introduction

- Urban Stormwater Management (USWM) systems are long-lasting investments

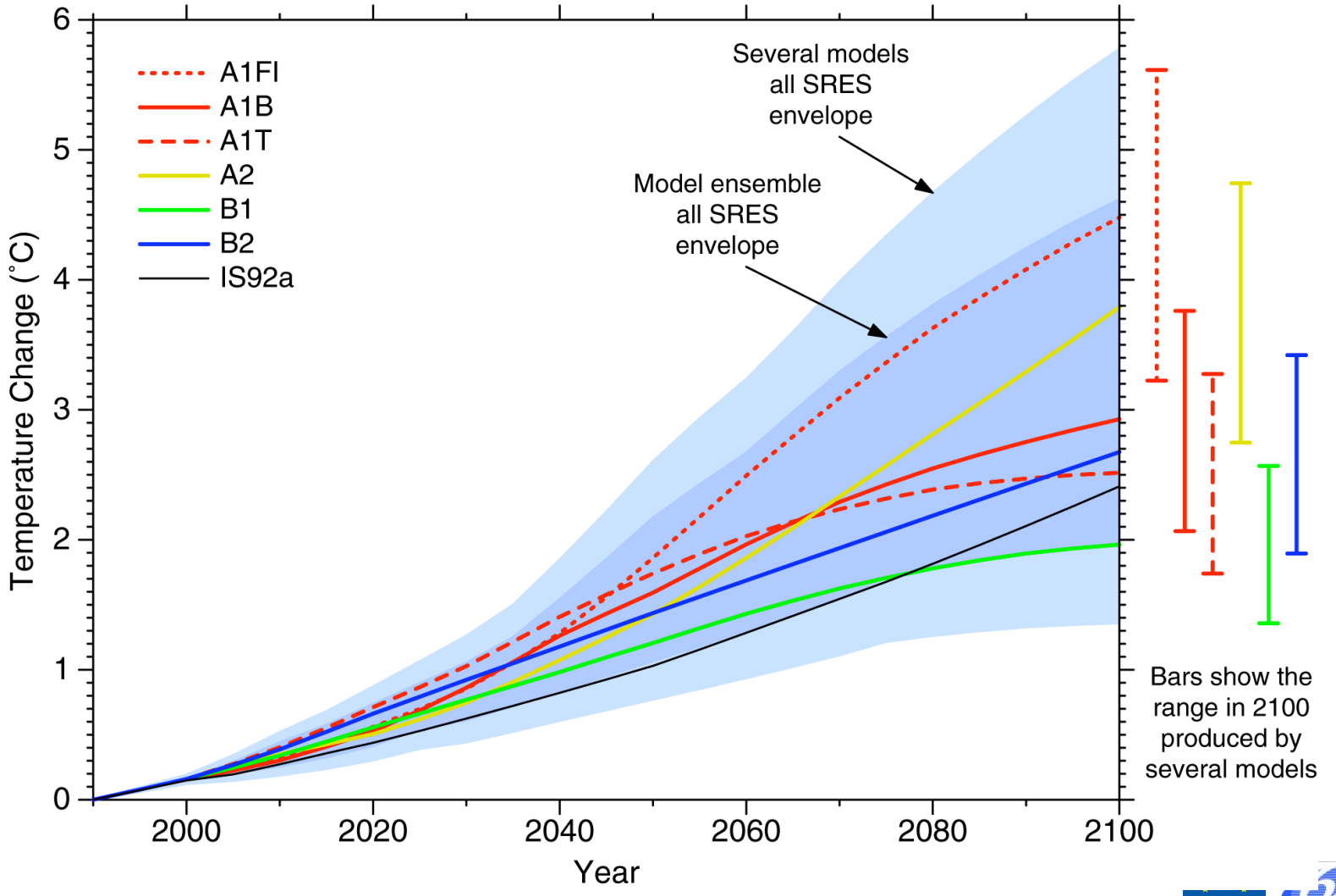
Type of installation	**Average life in years**
Sewers (new construction)	50 - 80 (100)
Pressure pipes and culverts	30 - 50
Tanks (CSO-tanks, clarifiers)	(40) 50 - 70
Pumping stations (construction part)	25 - 40
Gully (inlet)	40 - 80
Infiltration systems	20 - 40

According to LAWA (2005), Guideline for cost comparisons

Drivers for USWM



Problem of Prediction



Conclusion for USWM-Drivers

- Large number of drivers for USWM
- There are certainly future drivers we don‘t know about today
- For the known drivers, a prediction with a time horizon of 30-50 years is difficult or even impossible
- Drivers are often linked, what makes the development of scenarios even more difficult

- But, we have to design the USWM today!

One way out of the Dilemma

Take flexibility into account when assessing measures

- the ability of a system to respond to external changes affecting its value delivery, with little penalty in time, effort, cost or performance
- COFAS “Comparing the Flexibility of Alternative Solutions”
- Base: Utility Value Analysis
- Define indicators to measure the performance of different alternative solutions for each scenario

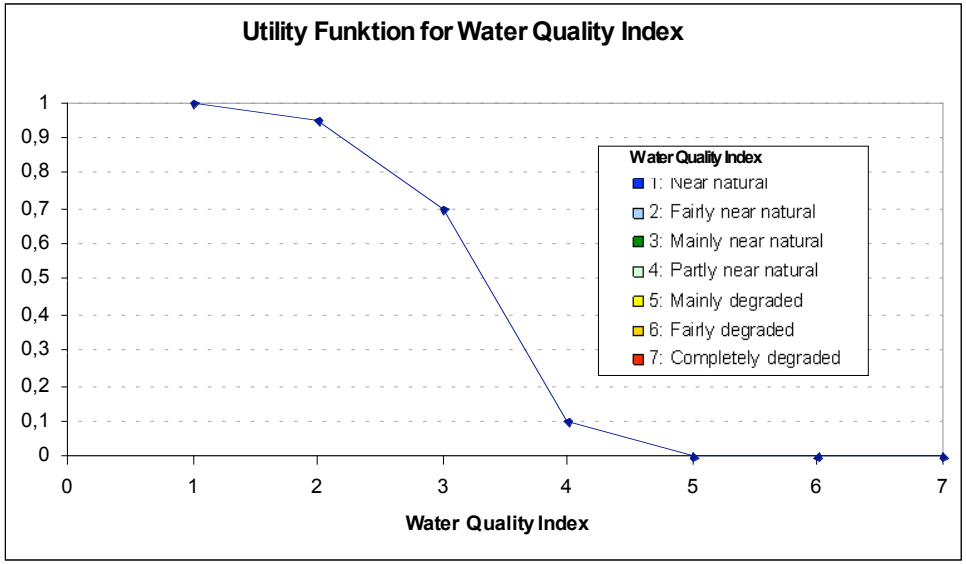
Flexibility

- Example: Stormwater master plan for Kupferzell, a small City in southern Germany
- Futures scenarios have been developed
- 4 different alternative solutions have been designed

Name of scenario	*Description*
Linear scenario (lin)	Extrapolation of the actual development based on statistical information.
Loading case scenario (lf)	Combination of the results of a sensitivity analysis with plausible extremes for the boundary conditions. Maximum load for the system.
Growth-oriented scenario	Boundary conditions for a individualistic and consumer-oriented
Combined sewer system (mw)	New areas will be drained with a combined sewer system
Separate sewer system (tw)	New areas will be drained with a separated sewer system
Decentralised system (dw)	Stormwater runoff from new areas will be managed with a decentralised infiltration system
Extended decentralised system (dwa)	Stormwater runoff from new areas will be managed with a decentralised infiltration system. In addition 20% of the existing impervious area will be disconnected, for another 20% green roofs will be implemented and 20% of the water supply will be covered by rainwater utilisation.

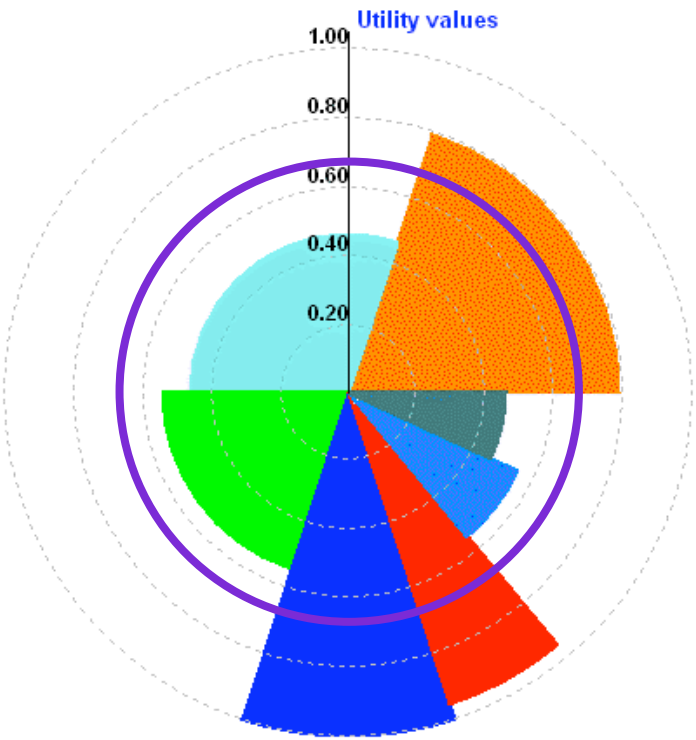
Utility Value Analysis (UVA)

- Classical method in Multi-Criteria Assessment
- Transformation of indicators => standardized values
- Definition of utility value functions

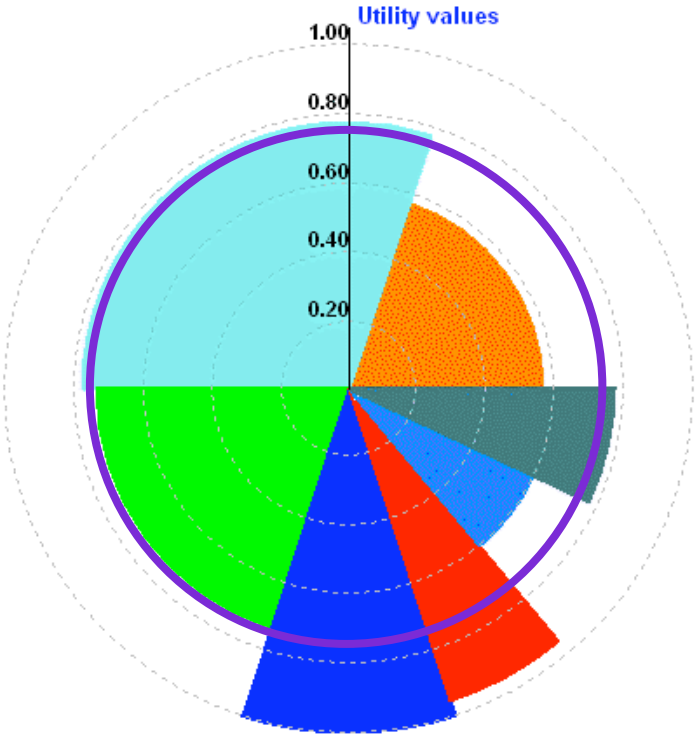


- Utility values are weighted...
- …and added to the total utility value

Homogeneity



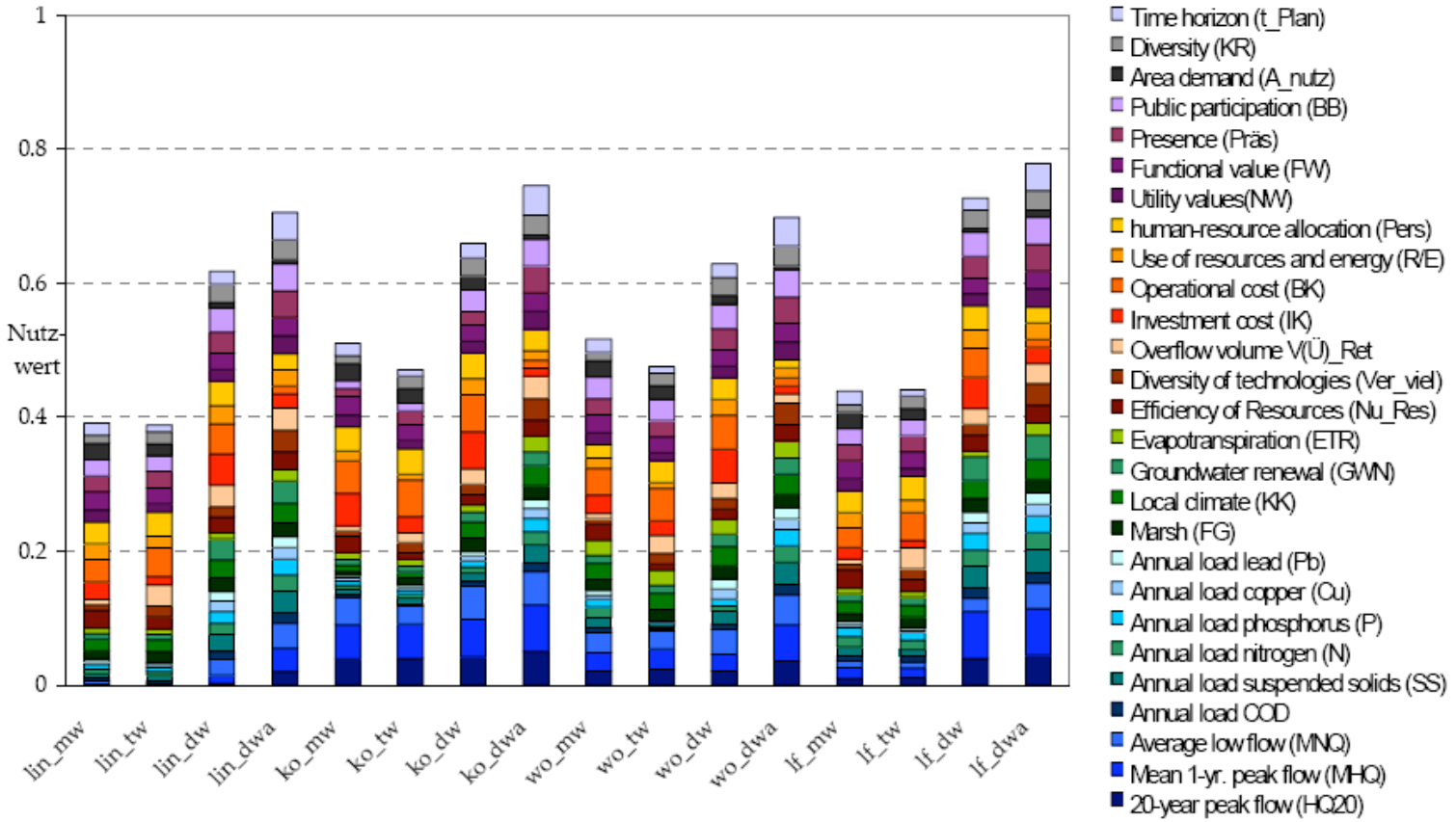
CSO Tank



SUDS

COD Load
Overflow freq.
WB: Infiltration
Peakflow 1yr
WB: Evapotrans.
Cost
WB: Runoff

Performance



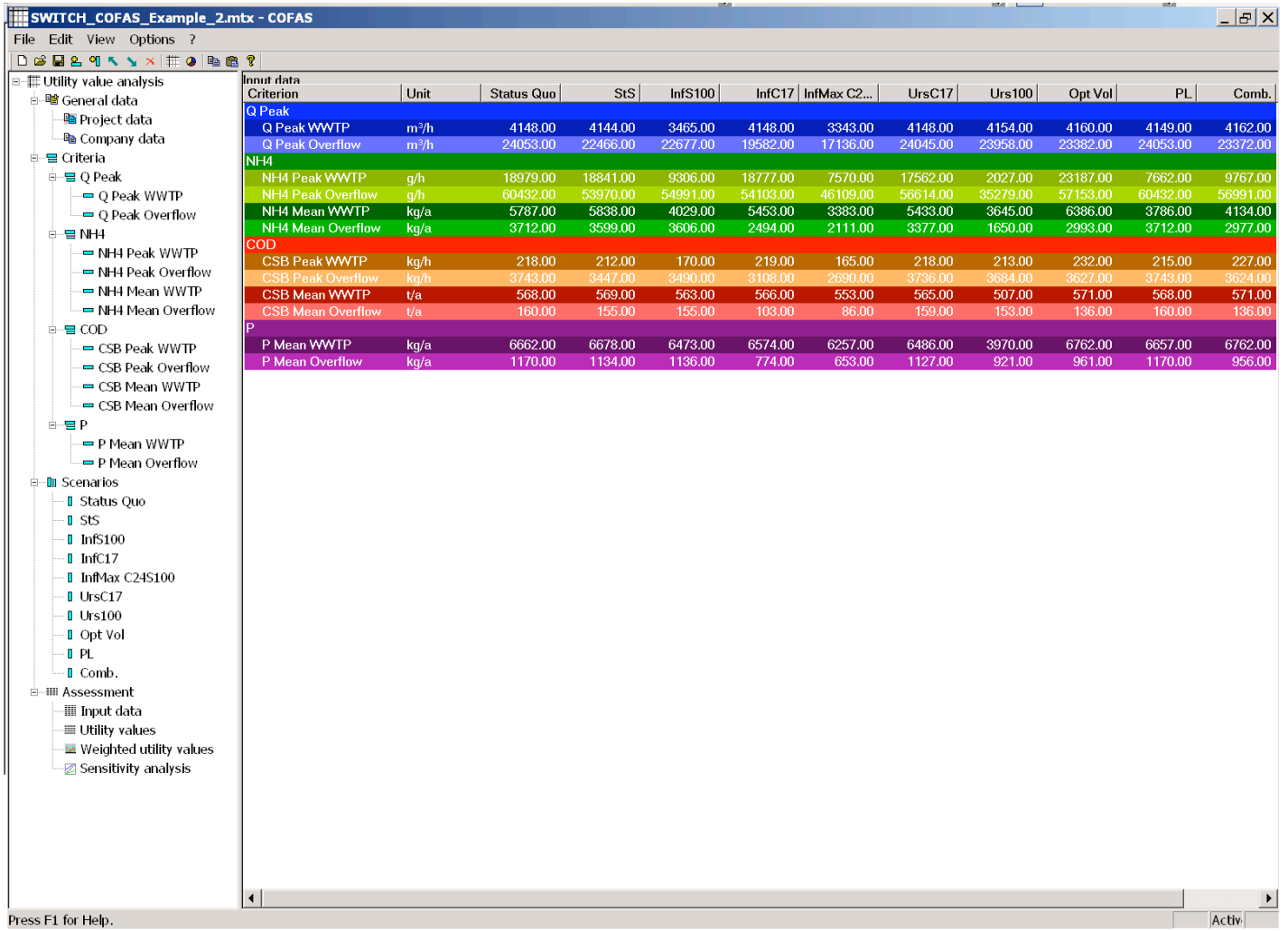
Results Case Study

all numbers in [%]	Combined sewer system	Separate sewer system	Decentralised system	Ext. decentr. system
Utility values				
Conservational scenario	51.4	47.4	66.4	74.1
Growth-oriented scenario	51.9	47.7	63.2	69.4
Linear scenario	39.3	38.8	61.9	70.1
Loading case scenario	44.1	44.1	72.9	77.5
Mean value	46.7	44.5	66.1	72.8
Internal homogeneity				
Conservational scenario	42.1	45.4	59.6	66.7
Growth-oriented scenario	61.6	40.0	65.6	64.2
Linear scenario	33.7	33.7	61.1	68.6
Loading case scenario	50.4	50.7	69.9	74.1
Mean value	46.9	42.4	64.1	68.4
External homogeneity				
	83.8	88.0	92.3	95.0
multi-dimensional, multi-variant Degree of Target Achievement (dvDTA				
	56.4	55.0	73.3	78.0

COFAS Software

- Flexibility assessment
- „Normal“ Scenario comparison
- Multi Criteria Analysis
- Mediating tool in learning alliances

COFAS Tool, Input data



Criterion	Unit	Status Quo	StS	InfS100	InfC17	InfMax C2...	UrsC17	Urs100	Opt Vol	PL	Comb.
Q Peak											
Q Peak WWTP	m³/h	4148.00	4144.00	3465.00	4148.00	3343.00	4148.00	4154.00	4160.00	4149.00	4162.00
Q Peak Overflow	m³/h	24053.00	22466.00	22677.00	19582.00	17136.00	24045.00	23958.00	23382.00	24053.00	23372.00
NH4											
NH4 Peak WWTP	g/h	18979.00	18841.00	9306.00	18777.00	7570.00	17562.00	2027.00	23187.00	7662.00	9767.00
NH4 Peak Overflow	g/h	60432.00	53970.00	54991.00	54103.00	46109.00	56614.00	35279.00	57153.00	60432.00	56991.00
NH4 Mean WWTP	kg/a	5787.00	5838.00	4029.00	5453.00	3383.00	5433.00	3645.00	6386.00	3786.00	4134.00
NH4 Mean Overflow	kg/a	3712.00	3599.00	3606.00	2494.00	2111.00	3377.00	1650.00	2993.00	3712.00	2977.00
COD											
CSB Peak WWTP	kg/h	218.00	212.00	170.00	219.00	165.00	218.00	213.00	232.00	215.00	227.00
CSB Peak Overflow	kg/h	3743.00	3447.00	3490.00	3108.00	2690.00	3736.00	3684.00	3627.00	3743.00	3624.00
CSB Mean WWTP	t/a	568.00	569.00	563.00	566.00	553.00	565.00	507.00	571.00	568.00	571.00
CSB Mean Overflow	t/a	160.00	155.00	155.00	103.00	86.00	159.00	153.00	136.00	160.00	136.00
P											
P Mean WWTP	kg/a	6662.00	6678.00	6473.00	6574.00	6257.00	6486.00	3970.00	6762.00	6657.00	6762.00
P Mean Overflow	kg/a	1170.00	1134.00	1136.00	774.00	653.00	1127.00	921.00	961.00	1170.00	956.00

Output Table

SWITCH_COFAS_Example_3.mtx - COFAS

File Edit View Options ?

- Utility value analysis
  - General data
    - Project data
    - Company data
  - Criteria
    - Q Peak
      - Q Peak WWTP
      - Q Peak Overflow
    - NH4
      - NH4 Peak WWTP
      - NH4 Peak Overflow
      - NH4 Mean WWTP
      - NH4 Mean Overflow
    - COD
      - CSB Peak WWTP
      - CSB Peak Overflow
      - CSB Mean WWTP
      - CSB Mean Overflow
    - P
      - P Mean WWTP
      - P Mean Overflow
  - Scenarios
    - Status Quo
    - StS
    - InfS100
    - InfC17
    - InfMax C24S100
    - UrsC17
    - Urs100
    - Opt Vol
    - PL
    - Comb.
  - Assessment
    - Input data
    - Utility values
    - Weighted utility values
    - Sensitivity analysis

Utility values

Criterion	Weight	Status Quo	StS	InfS100	InfC17	InfMax C2...	UrsC17	Urs100	Opt Vol	PL	Comb.
Q Peak	25.0	0.25	0.28	0.33	0.32	0.43	0.25	0.25	0.26	0.25	0.26
Q Peak WWTP	12.5	0.25	0.25	0.37	0.25	0.40	0.25	0.25	0.25	0.25	0.25
Q Peak Overflow	12.5	0.25	0.30	0.29	0.39	0.47	0.25	0.25	0.27	0.25	0.27
NH4	25.0	0.50	0.52	0.60	0.56	0.69	0.53	0.74	0.50	0.59	0.60
NH4 Peak WWTP	3.0	0.50	0.50	0.75	0.51	0.80	0.54	0.95	0.39	0.80	0.74
NH4 Peak Overflow	9.5	0.50	0.55	0.55	0.55	0.62	0.53	0.71	0.53	0.50	0.53
NH4 Mean WWTP	7.5	0.50	0.50	0.65	0.53	0.71	0.53	0.69	0.45	0.67	0.64
NH4 Mean Overflow	5.0	0.50	0.52	0.51	0.66	0.72	0.55	0.78	0.60	0.50	0.60
COD	25.0	0.50	0.52	0.52	0.56	0.60	0.50	0.53	0.51	0.50	0.51
CSB Peak WWTP	0.8	0.50	0.51	0.61	0.50	0.62	0.50	0.51	0.47	0.51	0.48
CSB Peak Overflow	11.8	0.50	0.54	0.53	0.58	0.64	0.50	0.51	0.52	0.50	0.52
CSB Mean WWTP	9.8	0.50	0.50	0.50	0.50	0.51	0.50	0.55	0.50	0.50	0.50
CSB Mean Overflow	2.8	0.50	0.52	0.52	0.68	0.73	0.50	0.52	0.57	0.50	0.57
P	25.0	0.50	0.50	0.51	0.53	0.56	0.51	0.69	0.51	0.50	0.51
P Mean WWTP	21.3	0.50	0.50	0.51	0.51	0.53	0.51	0.70	0.49	0.50	0.49
P Mean Overflow	3.8	0.50	0.52	0.51	0.67	0.72	0.52	0.61	0.59	0.50	0.59
Sum or weighted mean	100.0	0.44	0.45	0.49	0.49	0.57	0.45	0.55	0.45	0.46	0.47
Internal homogeneity		0.75	0.77	0.78	0.76	0.81	0.74	0.64	0.74	0.70	0.71
dZEG		0.57	0.59	0.62	0.61	0.68	0.58	0.60	0.58	0.57	0.58

Press F1 for Help.

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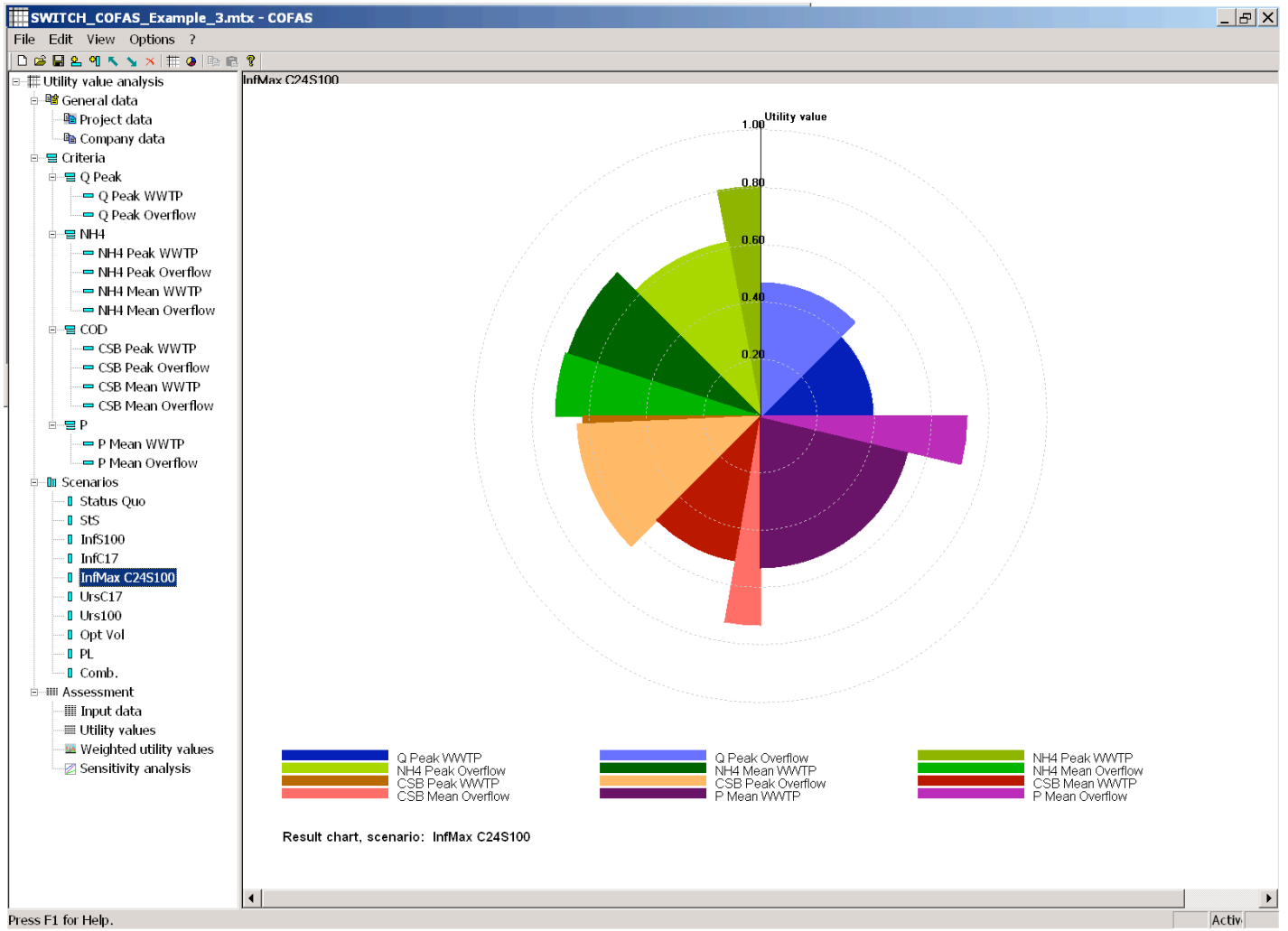
SIXTH FRAMEWORK PROGRAMME

Homogeneity



COFAS Download

- Download on the SWITCH Intranet (D 2.1.4)
  - http://www.switch.watsan.net/page/4748
  - Software
  - Example datasets
  - Documentation including introduction, tutorial and scientific background

Conclusion

- For many USWM drivers future changes are unpredictable
- Flexibility is an important decision making criteria
- With COFAS, flexibility of different solutions can be measured and compared
- Decentralized systems (SUDS, source control) tend to be more flexible then conventional end of pipe systems

Thank you for your attention

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