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hanseWasser

Moin!

Energy analysis by set of rules DWA A-216e

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Agenda

→Our WOP: Who works together and how we work together

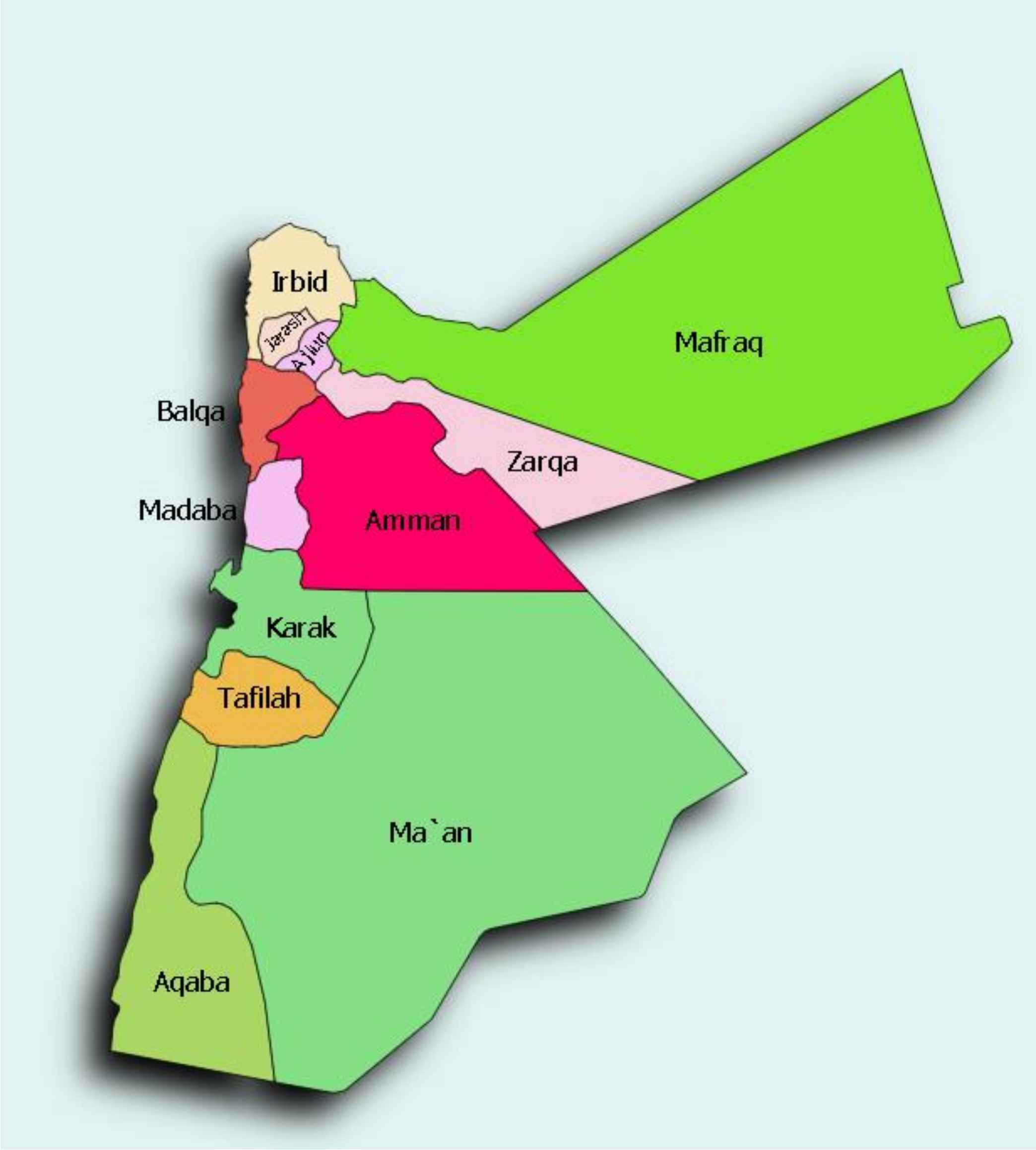
→Set of rules DWA A-216e

→WOP result: Energy analysis WWTP Madaba (Jordan)

→Experiences by implementation

→Discussion

Source: https://www.google.de/maps/place/Deutschland/...



Source: paintmaps.com

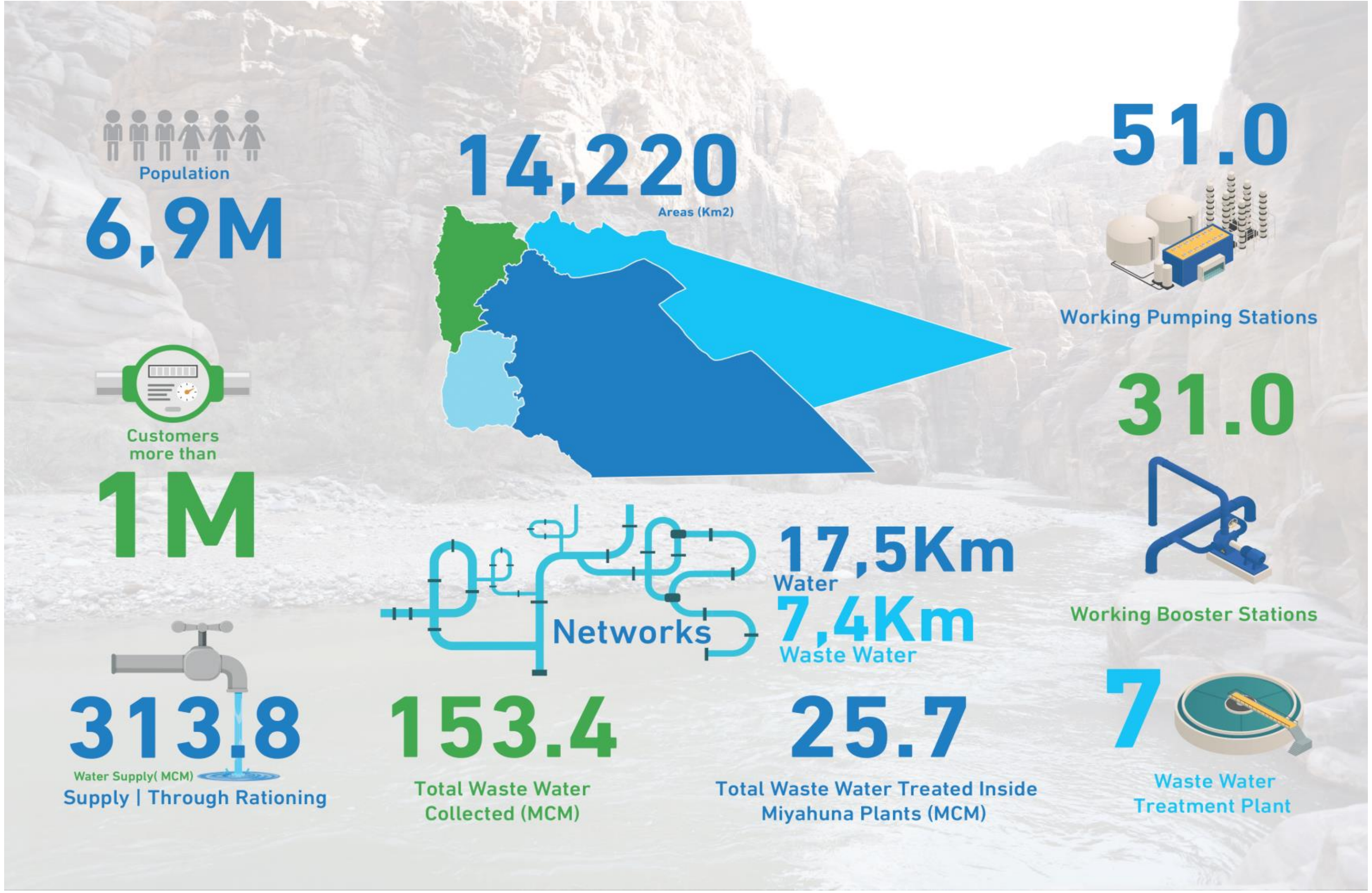
WOP: German-Jordanian Water Operators Partnership

→ Miyahuna (Jordan), hanseWasser and Hamburg Wasser (Germany) started in April 2021 long term partnership for know-how-transfer.

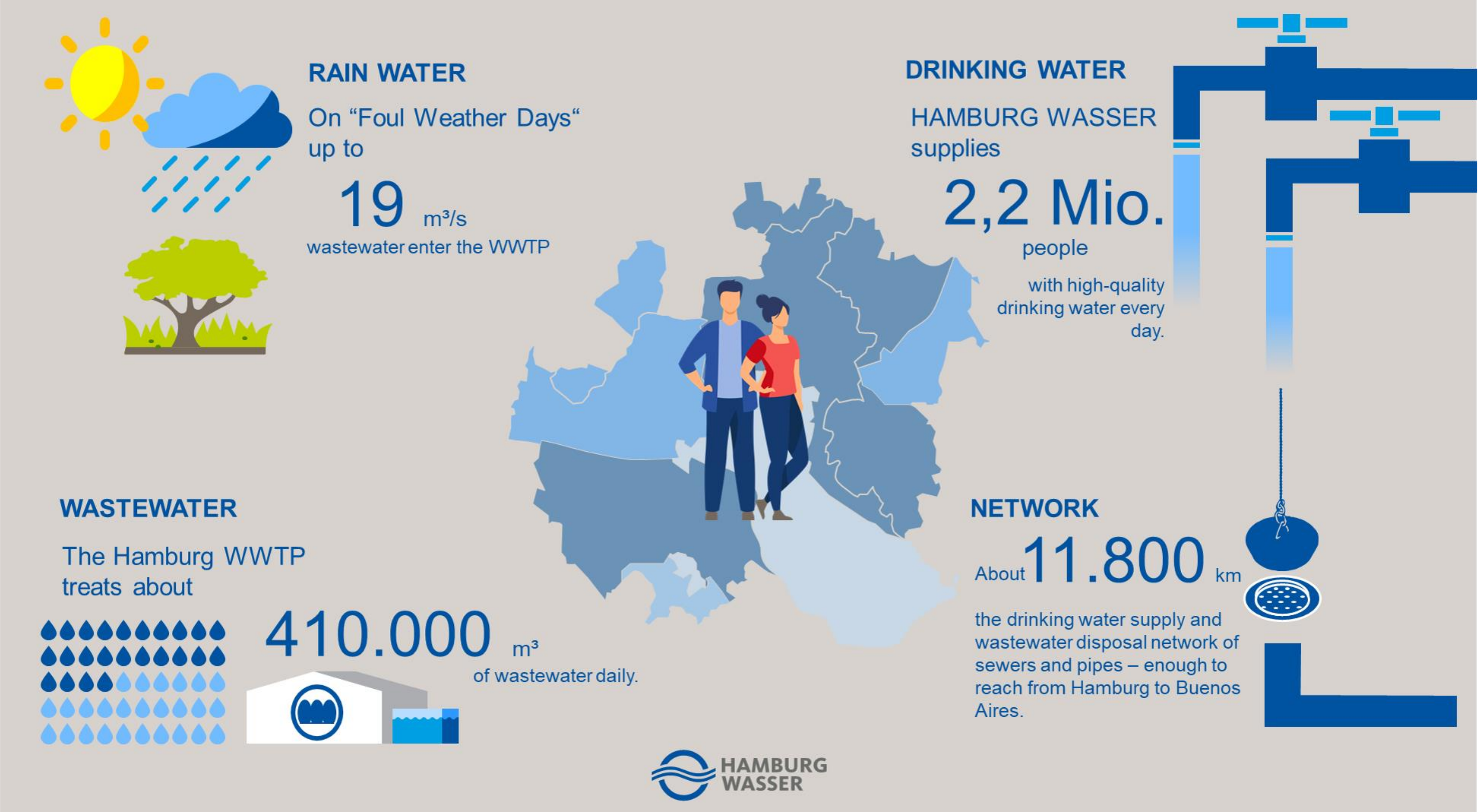
← **speakers for this presentation**

→ One of the main goals is to make the operation of WWTP more energy-efficient.

Jordan Water Company Miyahuna



Hamburg Wasser



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Netze BW Wasser (NWA)
- Facts and Figures

Netze BW

Area: **207 km²**
Population: **604.166**

342 m height difference

Network length: 2.526 km
VW 1.389 km (distribution network)
AW 1.005 km (household connections)
ZW 132 km (transporatation pipes)

Connections: ~ 76.000 pieces
Water meters: ~ 105.000 pieces
Fittings in system: ~17.000 pieces

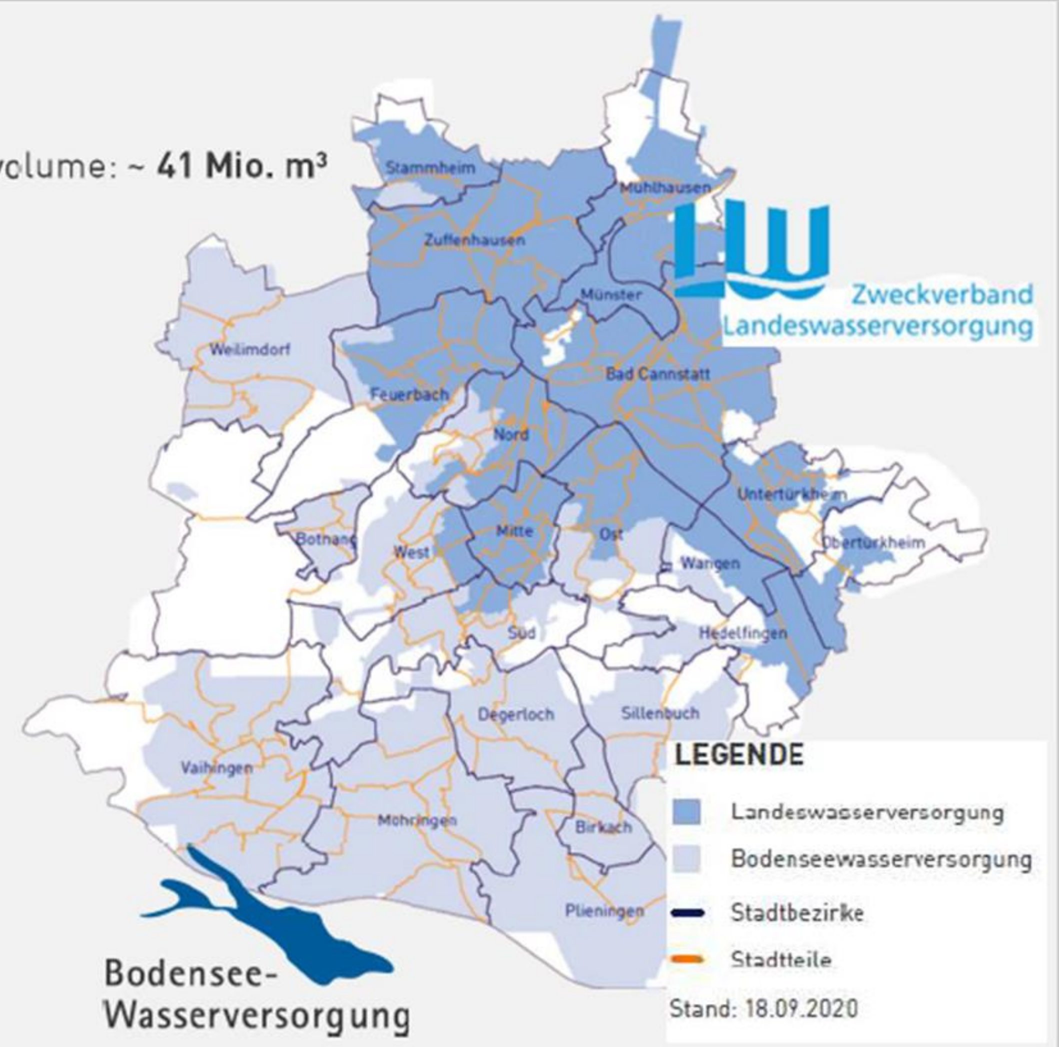
Amount of **water samples** in supply area:
28.200 samples

Ann. system input volume: ~ **41 Mio. m³**

41 water reservoir
at ~ 160 T m³ Capacity
68 pressure zones

38 pumping stations and
17 Turbines
>3 million GWh per year
energy recovery

costs per glass of water
(250 ml): **0,0716 Cent**



Reference year of key figures 2021


1 WWTP Farge


2 Control Center Seehausen


2 WWTP Seehausen


3 Headquarter


4 Pressure Pipe Findorff


5 Stormwater Basin MVA


6 Main Pumping Station Findorff

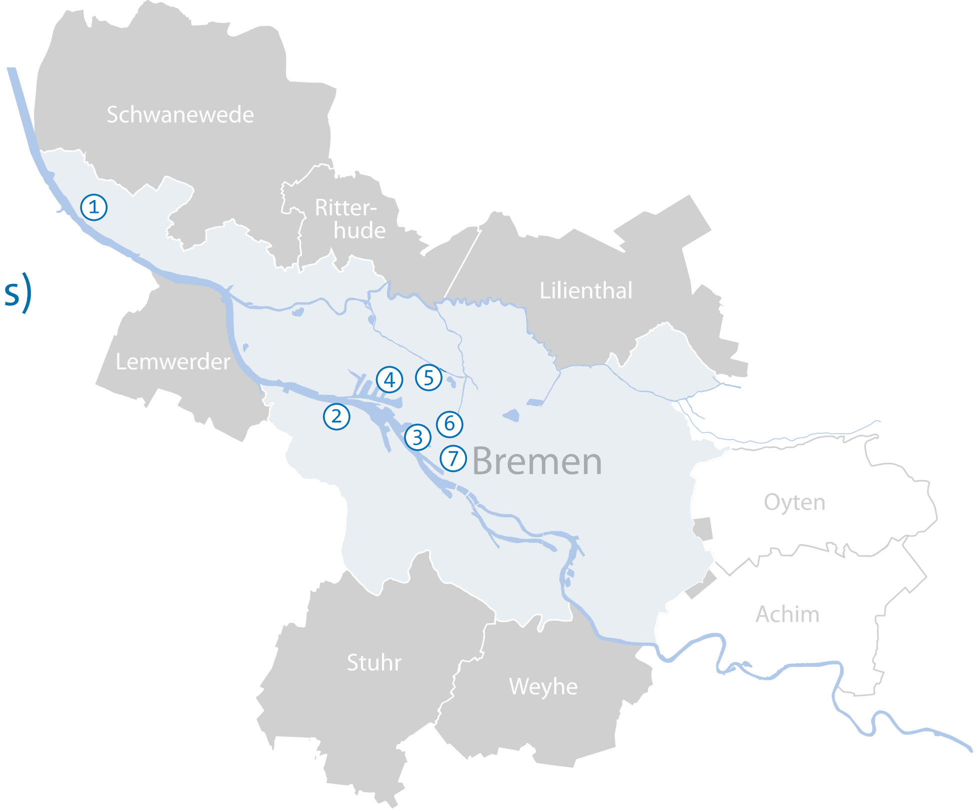

7 Sewer flow steering Stern

hanseWasser

Sewer system

(Mixed and separated Systems)

- → 2,200 km sewer network
- → 130 km pressure pipes
- → 200 pumping stations, Stormwater basins
- → Storage volume for stormwater events 270,000 m³
- → 230 km Sewer-CCTV-Inspection per year
- → Sewer information system
- → 700 km sewer cleaning per year
- → Operational sewer information system



Treatment

WWTP Seehausen 1,000,000 Inh

WWTP Farge 160,000 Inh

Partnership Activities

→ 4th Networking Event of the Utility Platform 30th/31st of May 2022 in Stuttgart, Germany

→ IFAT Munich 2022

→ Visits on each others plants in Germany and Jordan

Expectations for the WOP

→Strengthen the capacity of human resources to reach improved overall performance of operators and enable them to continue long term improvements once partnerships came to the end.

→Specific technical assistance and training programs in:

- → Energy analysis and energy efficiency
- →Anaerobic sludge treatment and renewable energy (biogas and solar energy)

Our WOP Approach

WOP Approach

WWTP	Bremen-Farge
Year of record	2020

WOP Approach

Value	Unit	WWTP South Amman	WWTP Madaba	WWTP Farge	WWTP Seehausen
Design capacity	$PT_{BOD,60}$		214,000	160,000	980,000
Total number of inhabitants	$PT_{COD,120}$	155,245	72,088	110,518	854,516
and population equivalents (PT)	$PT_{BOD,60}$	198,250	92,797	143,339	916,067
polulation equivalents american standard	$PT_{BOD,65}$	183,675	85,658	132,320	845,600
Energy consumption WWTP	kWh/a	11,907,570	2,870,673	2,416,258	22,944,378
Energy consumption aeration	kWh/a	8,794,280	1,578,870	1,513,447	10,848,135
Specific energy demand	$kWh/(PT_{COD,120}*a)$	76.7	39.8	25.3	26.9
Specific energy demand	$kWh/(PT_{BOD,65}*a)$	64.8	33.5	18.3	27.1

Why DWA-A 216?

Set of rules DWA A-216

- **Guidance to reduce energy demand of WWTPs**
  - „Energie in ARA“, Bundesamt für Energie, Schweiz, 1994
  - Handbuch „Energie in Kläranlagen“, MURL, NRW,1999
  - Leitfaden „Senkung des Stromverbrauchs auf Kläranlagen“ DWA-LV BW, 2008
  - „Leitfaden für die Erstellung eines Energiekonzeptes kommunaler Kläranlagen, Wien, 2008

- **Inventory for WWTPs**
  - „Stromverbrauch auf kommunalen Kläranlagen“, LfU, 1998
  - „Steigerung der Energieeffizienz auf kommunalen Kläranlagen“, UBA, 2008
  - DWA-Leistungsvergleich Kläranlagen, Bad Honnef, 2011

Set of rules DWA A-216

➢ Conditions for energy efficiency

- Criteria and reference size?
- Methodology for determining the optimum or for characterizing the best possible energy efficiency?
- Comparability of treatment procedures, concepts, size categories?

➢ Mandate to the DWA:

- Development of a nationwide instrument for verifying energy efficiency

Home - DWA - German Association for Water, Wastewater and Waste

Set of rules DWA A-216

What is the DWA Set of Rules?

Technical standards are an important factor in efficaciously and economically protecting the environment and material goods and in promoting quality assurance. The DWA therfore incorporates into its standards the most recent findings on time-tested procedures. The DWA Set of Rules consists of Standards and Guidelines and is prepared by more than 2400 specialists, who are engaged in the association in an honorary capacity and work in more than 340 specialist committees and working groups.

The DWA Set of Rules is viewed in Germany as the general basis for planning, construction and operation of plants in water, wastewater and waste management, as well as in soil conservation. It makes a considerable contribution to keeping the cost of environmental protection at a reasonable level. With this Set of Rules, the associations assume individual responsibility for their specific areas of expertise and unburden the state to a considerable extent: it should be noted that the DIN standards and the rules and standards of the DWA are of equal importance.

DWA-A 216E (Energy Check/12/2015)

Set of rules DWA A-216

- **Water Quality**

Foreword DWA-A 216

„... In doing so, these efforts to improve the energy efficiency should not contravene the primary purpose of urban drainage, that is discharge and treatment of wastewater with the objective of protecting the waterbodies....“
(A216, DWA, Dezember 2015)

- **Content divided:**

Energy Check

Energy Analysis

Energy Check

Example:

WWTP Size category 4 (10,000 – 100,000 Inhabitants)

E_{tot} = 453,079 kWh/a

PT_{COD} = 10,215 (120g COD/d = 1 Inhabitant)

$e_{tot} = E_{tot} / PT_{COD}$

e_{tot} = 453,079 / 10,215 [kWh/(Inh*a)]

e_{tot} = 44.4 kWh/ (Inh*a)

Energy Check

Example:

WWTP Size category 4 (10,000 – 100,000 Inhabitants)

E_{aer} = 220,521 kWh/a

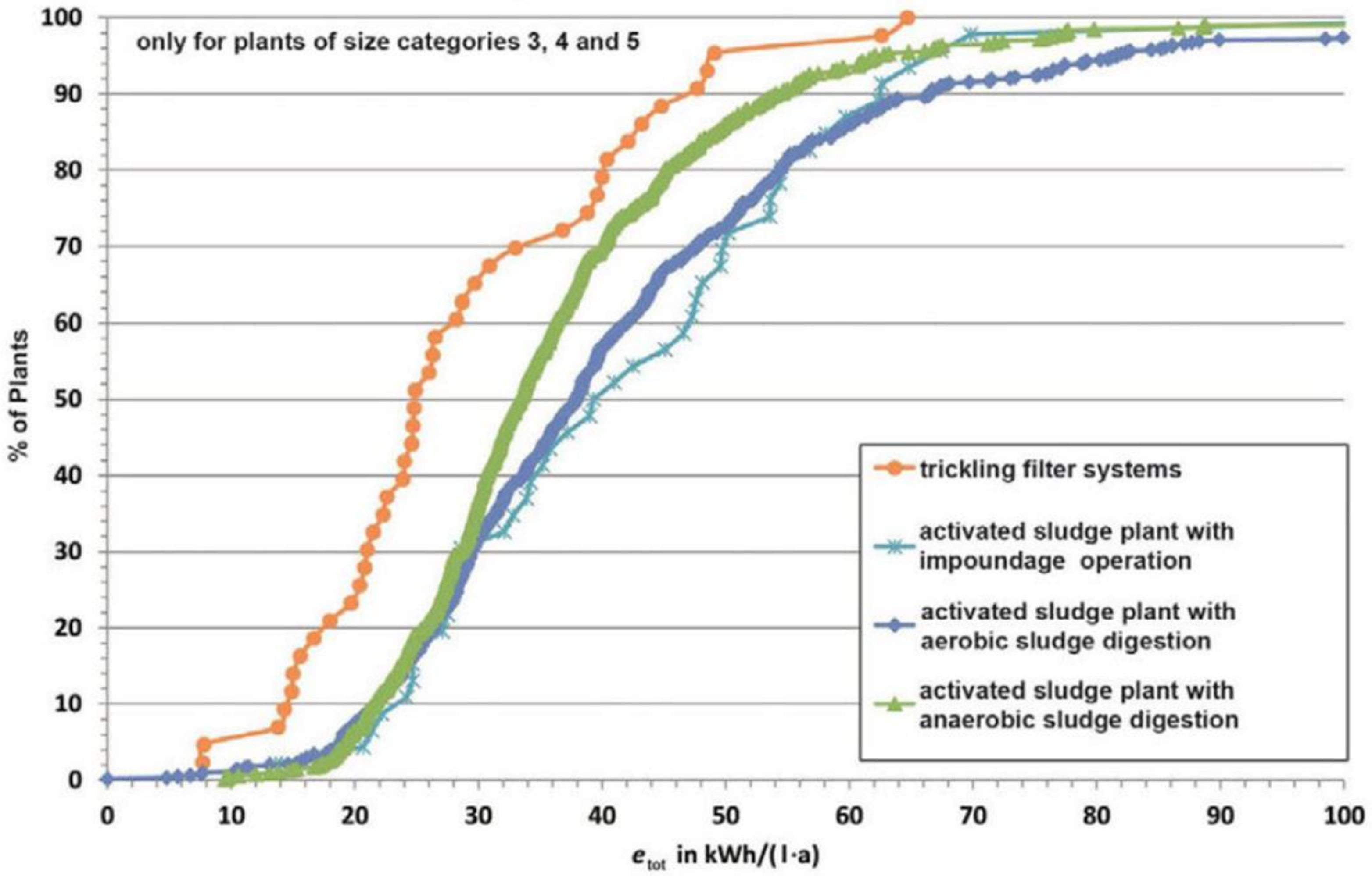
PT_{COD} = 10,215

$e_{aer} = E_{aer} / PT_{COD}$

e_{aer} = 220,521 / 10,215 [kWh/(Inh*a)]

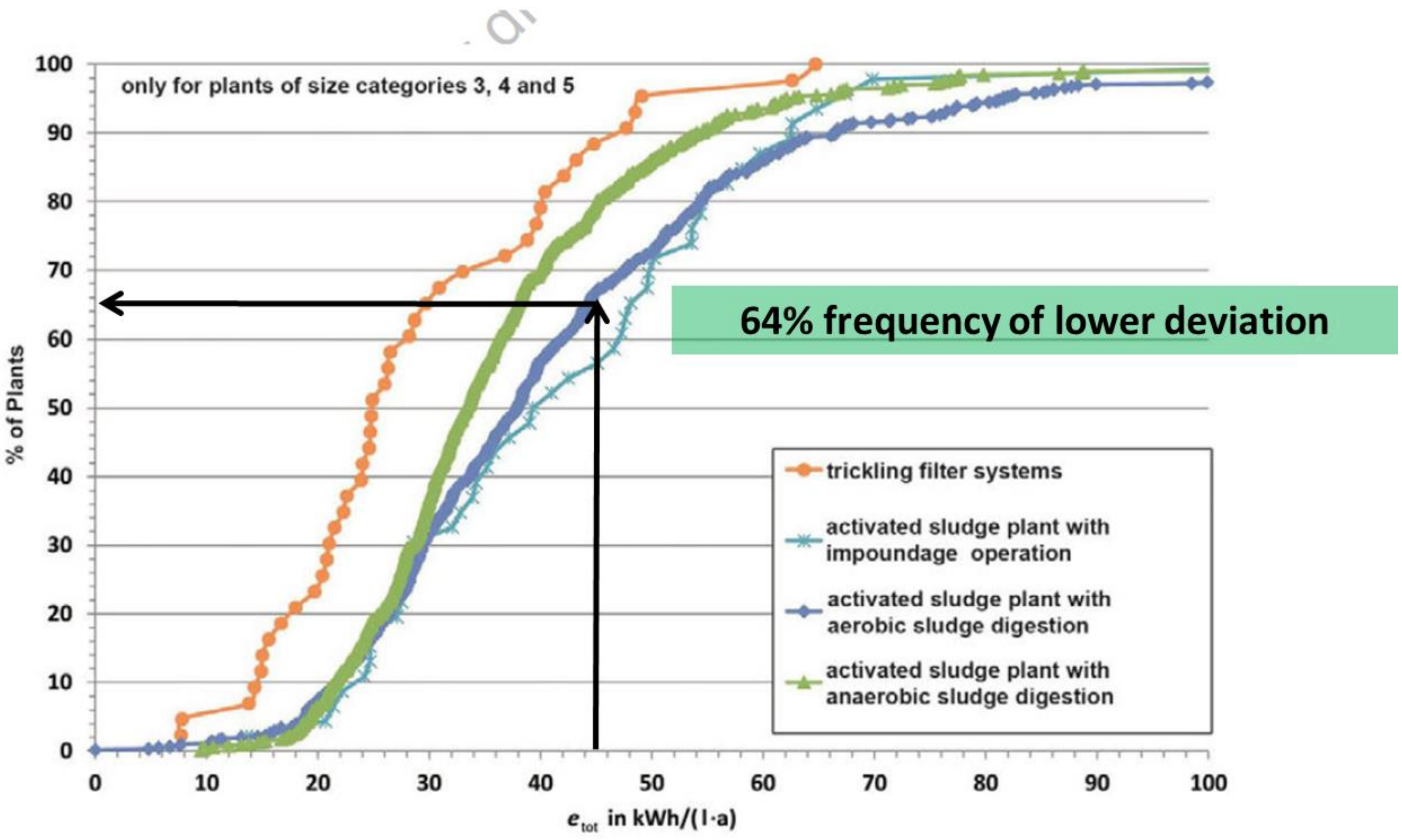
e_{aer} = 21.6 kWh/ (Inh*a)

Energy Check



Figures 1 and 2: Specific total power consumption depending on the cleaning process

Energy Check



Figures 1 and 2: Specific total power consumption depending on the cleaning process

Energy Check

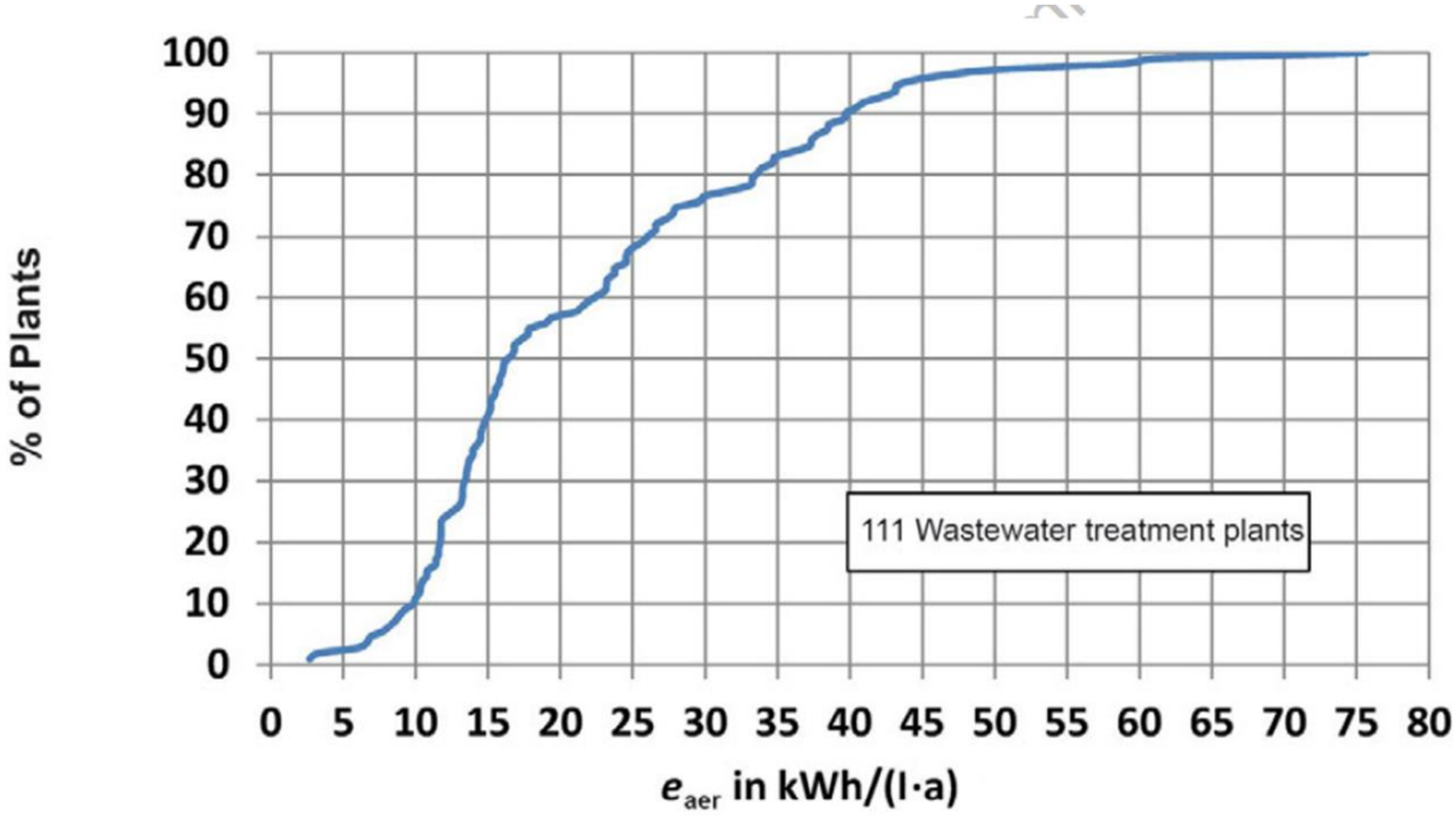
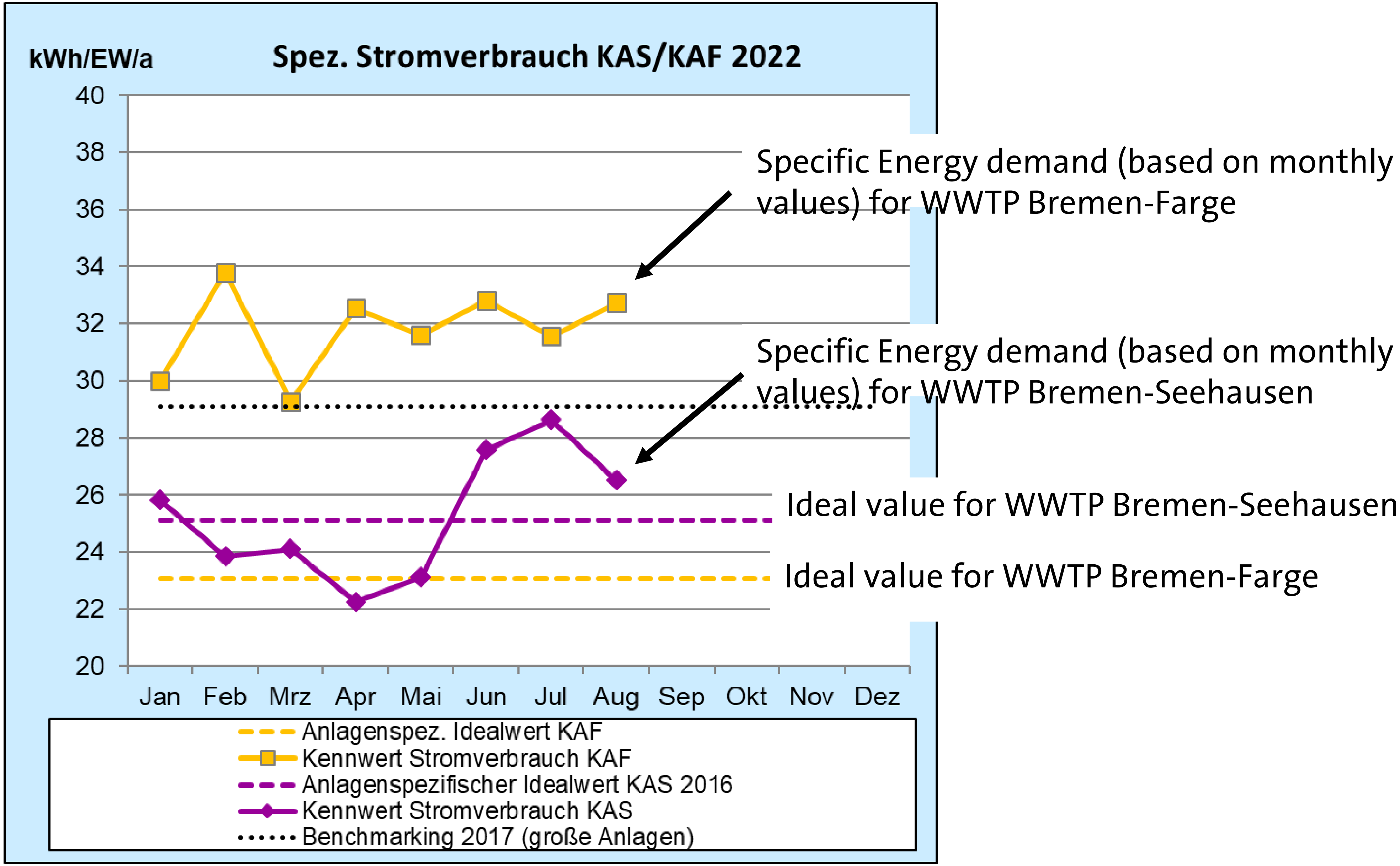
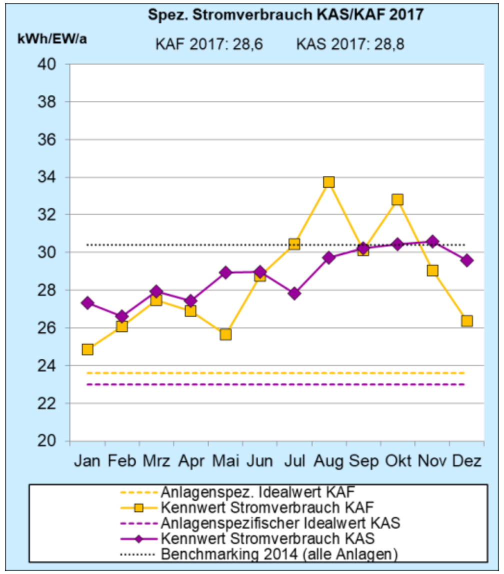


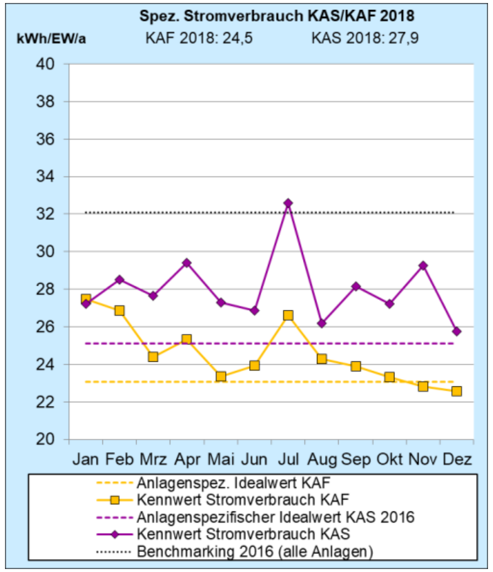
Figure 3: Specific power consumption of the aeration e_{aer} of a wastewater treatment plant

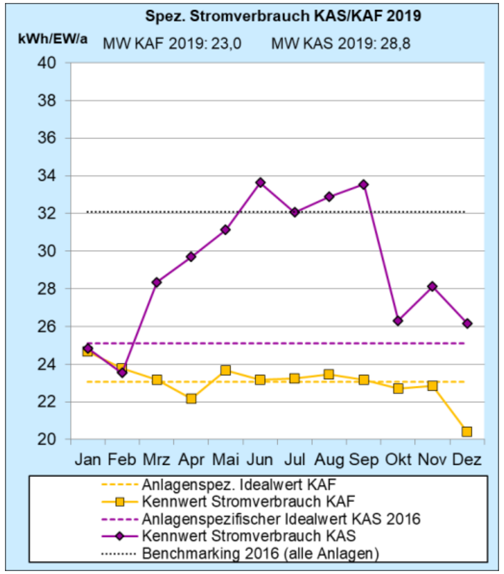
Energy Check

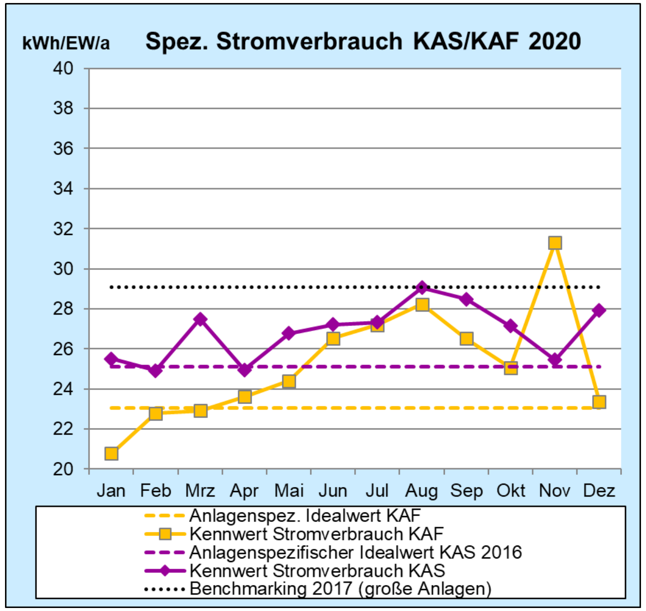


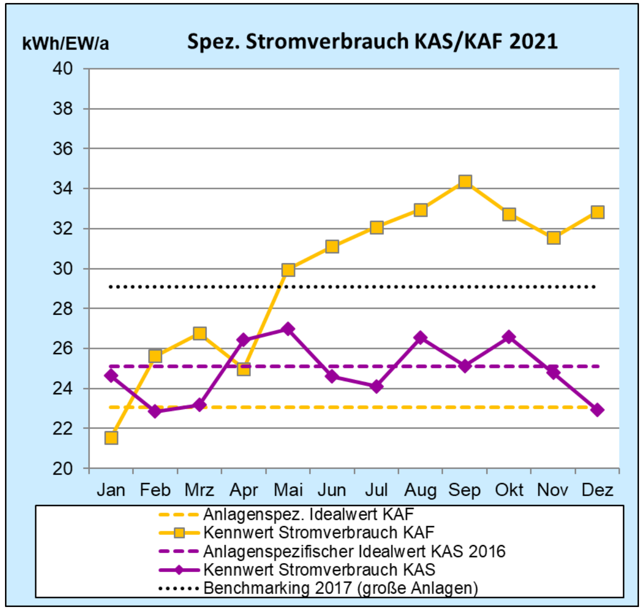
Energy Check

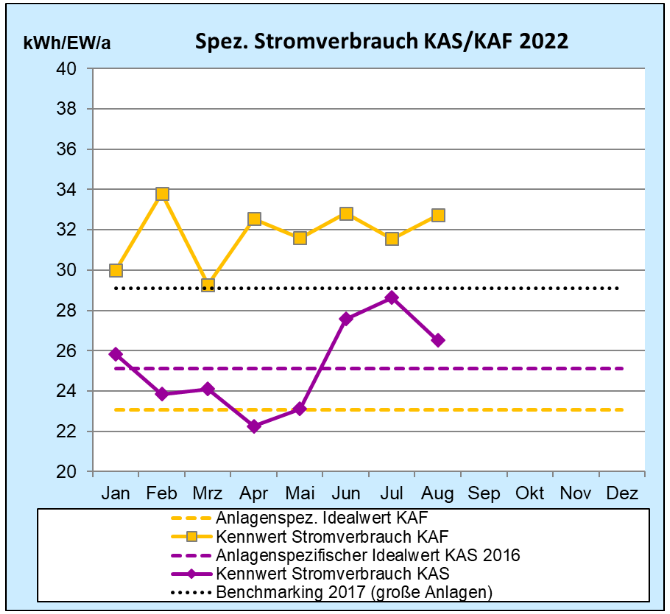












Energy Check

Further specific values

WWTP with digestion:

- specific digester gas production related to the total number of inhabitants and population Equivalents
- specific digester gas production related to the organic dry mass
- rate of digester gas conversion into electricity
- degree of selfsupply of electricity
- specific external heat consumption

Pumping station:

- specific total power consumption for pumping station

Summary Energy Check

- The energy check classifies the waste water treatment plant in comparison to other sewage treatment plants and gives an indication of whether it makes sense to carry out an energy analysis
- It is a good tool to show long-time effects on energy demand
- It does not provide any information about ways to save energy
- A detailed energy analysis is required for specific measures

Energy Analysis

- Detailed survey and evaluation of the energy situation based on a complete consumer matrix
- Derivation of optimization measures
- Economic evaluation of optimization measures
- Classification of optimization measures

Energy Analysis

The measures identified are divided into three priority levels:

- Immediate measures (S)
- Short-term measures (K)
- Dependent Actions (A)

Energy Analysis

- **Immediate measures (S)**

  Measures that are easy to implement without major investment and planning effort.

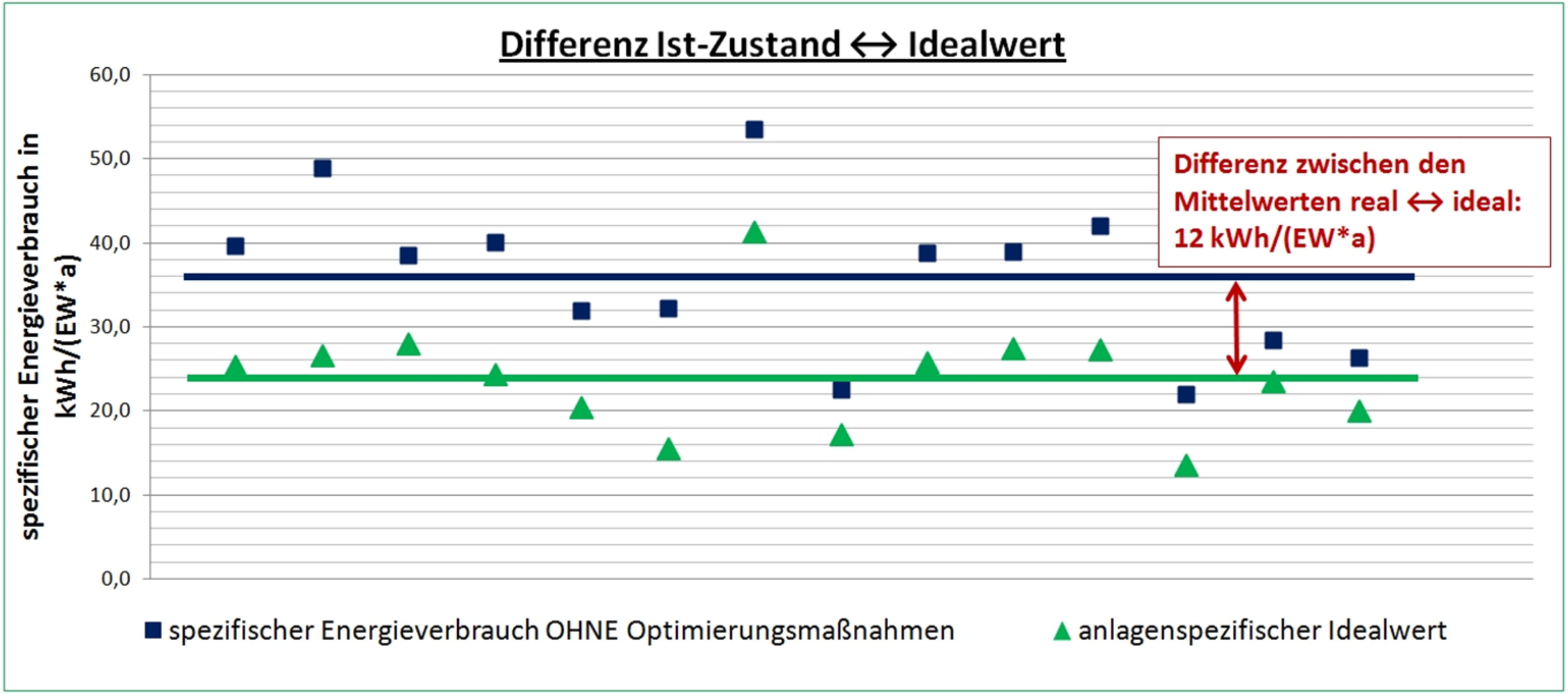
- **Short-term measures (K)**

  Measures that are classified as economically and technically feasible in the energy analysis and that are proposed for short-term processing and implementation.

- **Dependent Actions (A)**

  Measures that, due to an unfavorable cost-benefit ratio or other dependencies, can only be implemented as part of new buildings or conversions that are due anyway.

Energy Analysis

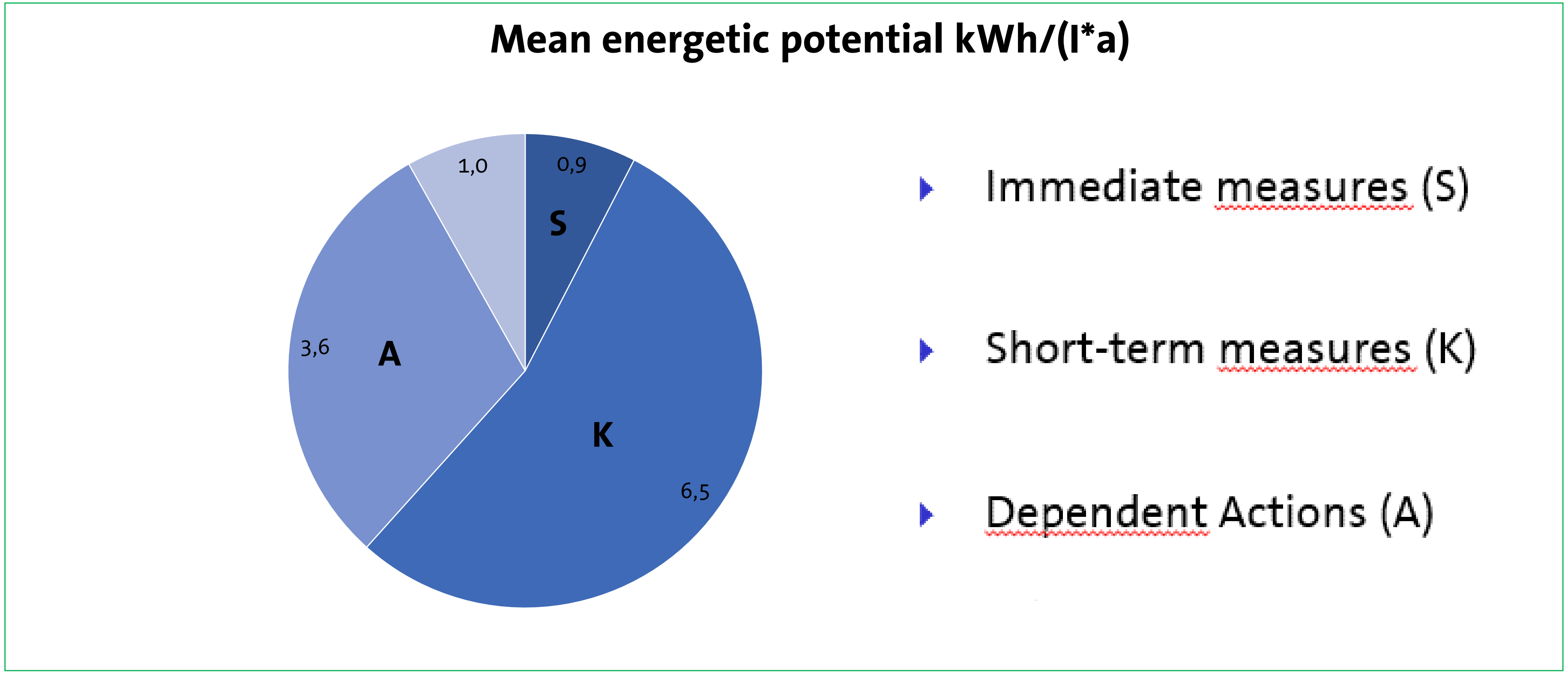


→ **Which part of this theoretical potential can actually be leveraged?**

Energy Analysis

→More than 92% of the theoretically potential can be reached by concrete measures

→**21%** of the whole energy consumption of all (German) plants can be saved only by implementing immediate and short-term measures



Summary DWA-A 216e

- The Energy Check by DWA A-216 is a good tool to monitor energy demand and efficiency by defined specific values

- For our WOP (Part Waste Water) theses specific values were the starting point to formulate concrete work packages by comparing our WWTPs

- The set of rules DWA A-216 is a good tool to classify the actual energy requirement of a WWTP and to estimate the ideal energy requirement

- There are also other ways to get more energy efficient that could be better for your actual starting point

Application of DWA-A 216 on WWTP Madaba

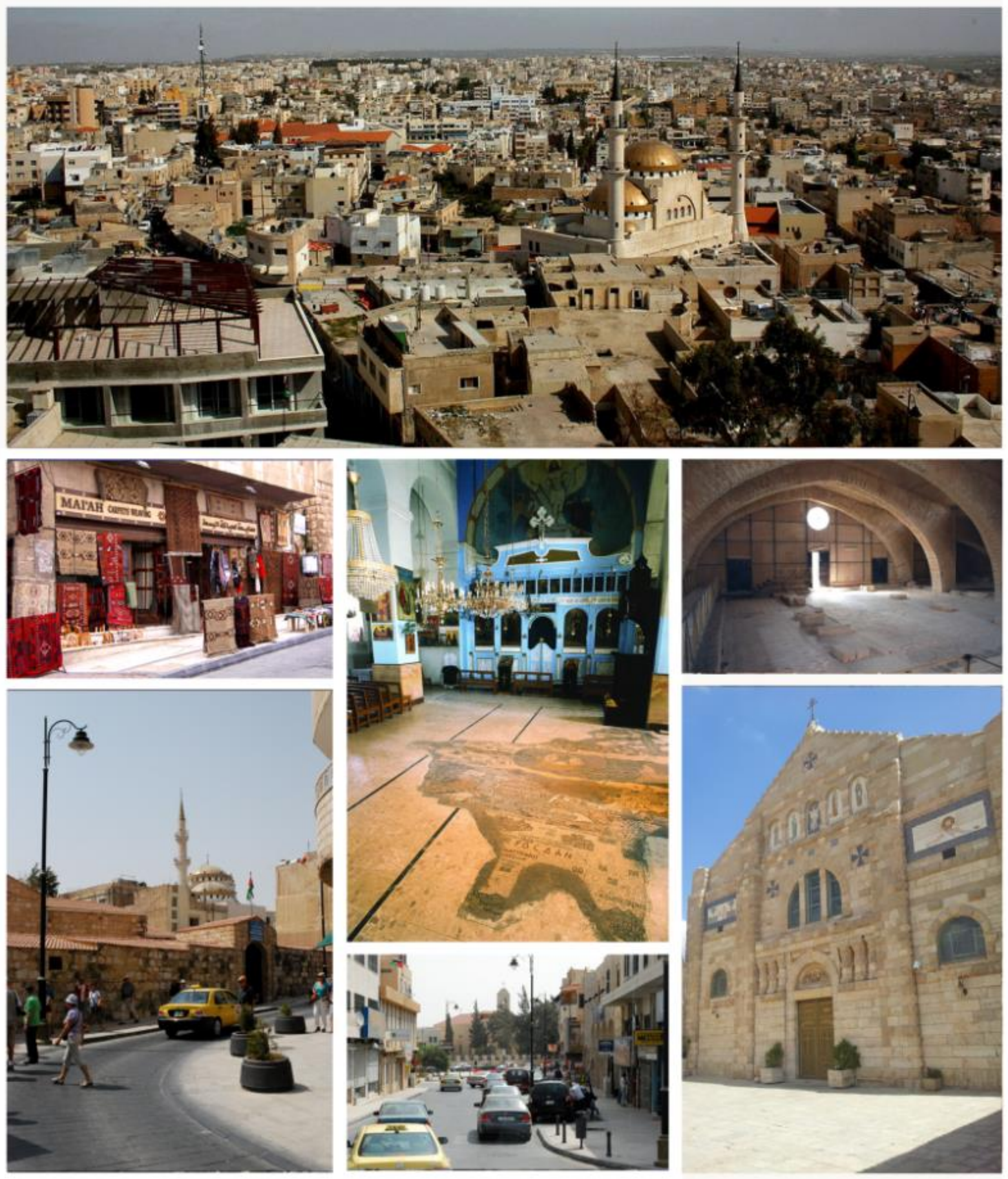
Madaba city

→Population 214,100 people, city is still growing fast

→ Area 1,000 km²

→Sewage Subscribers services

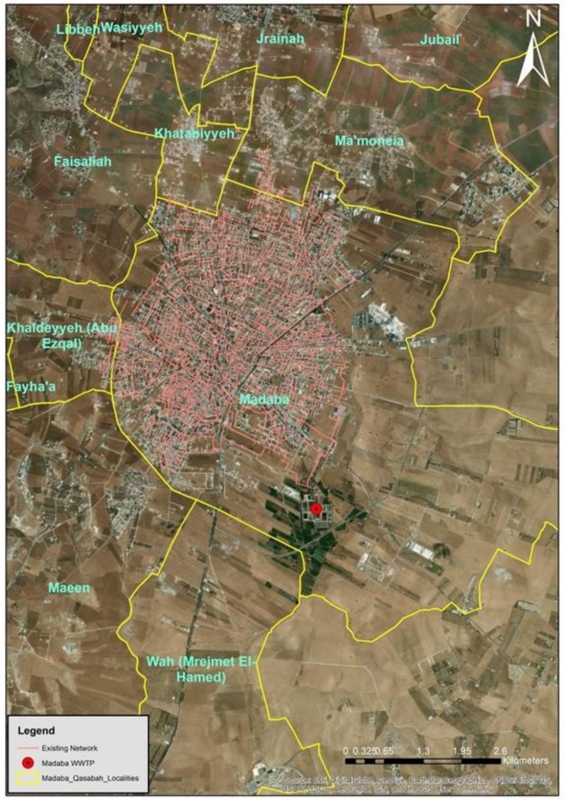
- → total water subscribers in Madaba city is 32,000
- → Sewage subscribers is 20,100 (65%)



Madaba WWTP + sewer network

Madaba WWTP

Madaba Sewer Network



Madaba WWTP

MWWTP was a lagoon-based treatment system built in 1986

Capacity : 2,000 m³/day

In 2002 the plant was expanded and upgraded to biological treatment (secondary)

Capacity : 7,600 m³/day

The plant receives wastewater from Madaba city networks (serve 60 %) as well as trucked septage (5%)

The WWTP Effluent standard is per JS893/2021 category 3c

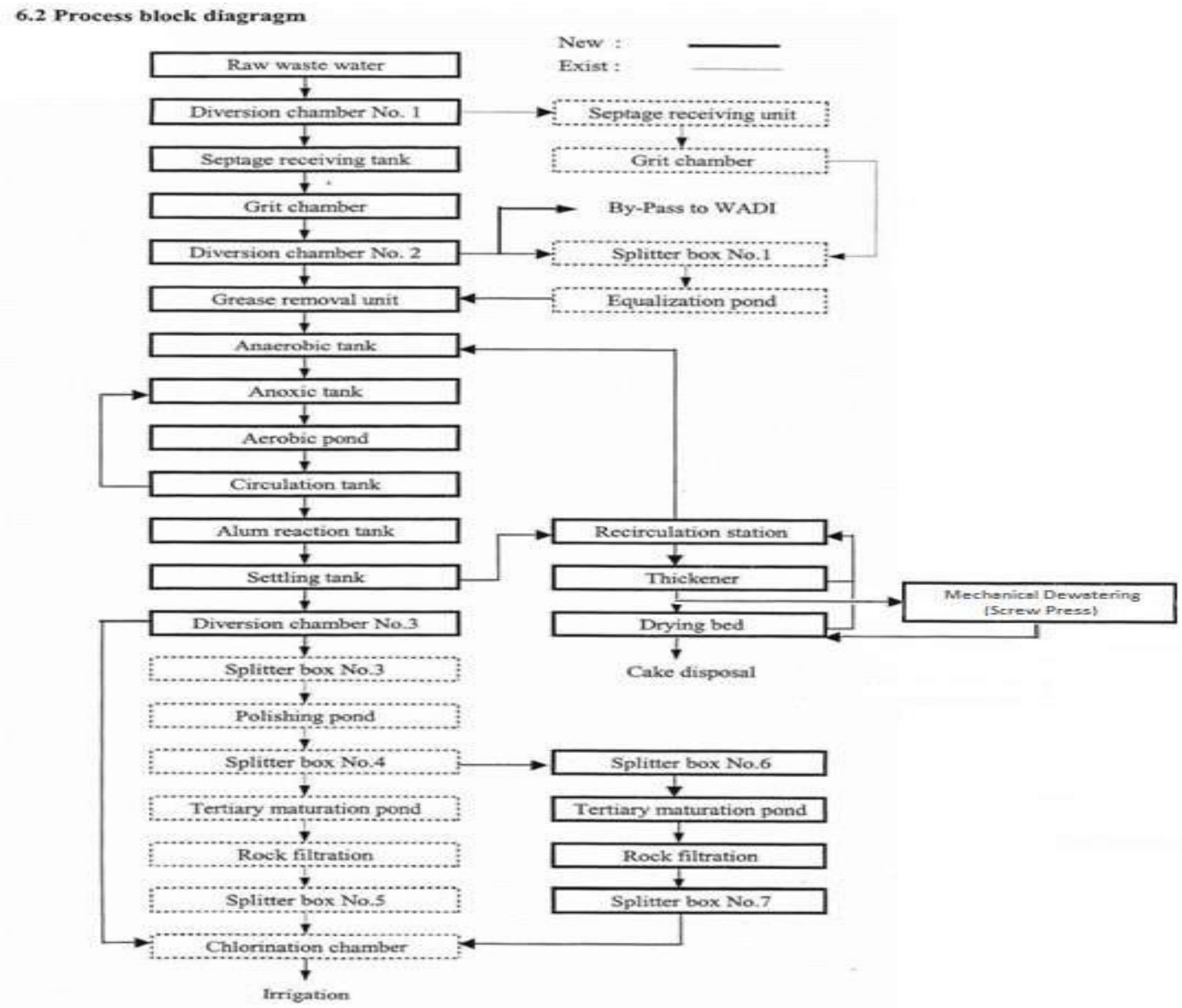
(field crops)

Madaba WWTP - Design & Reference Conditions

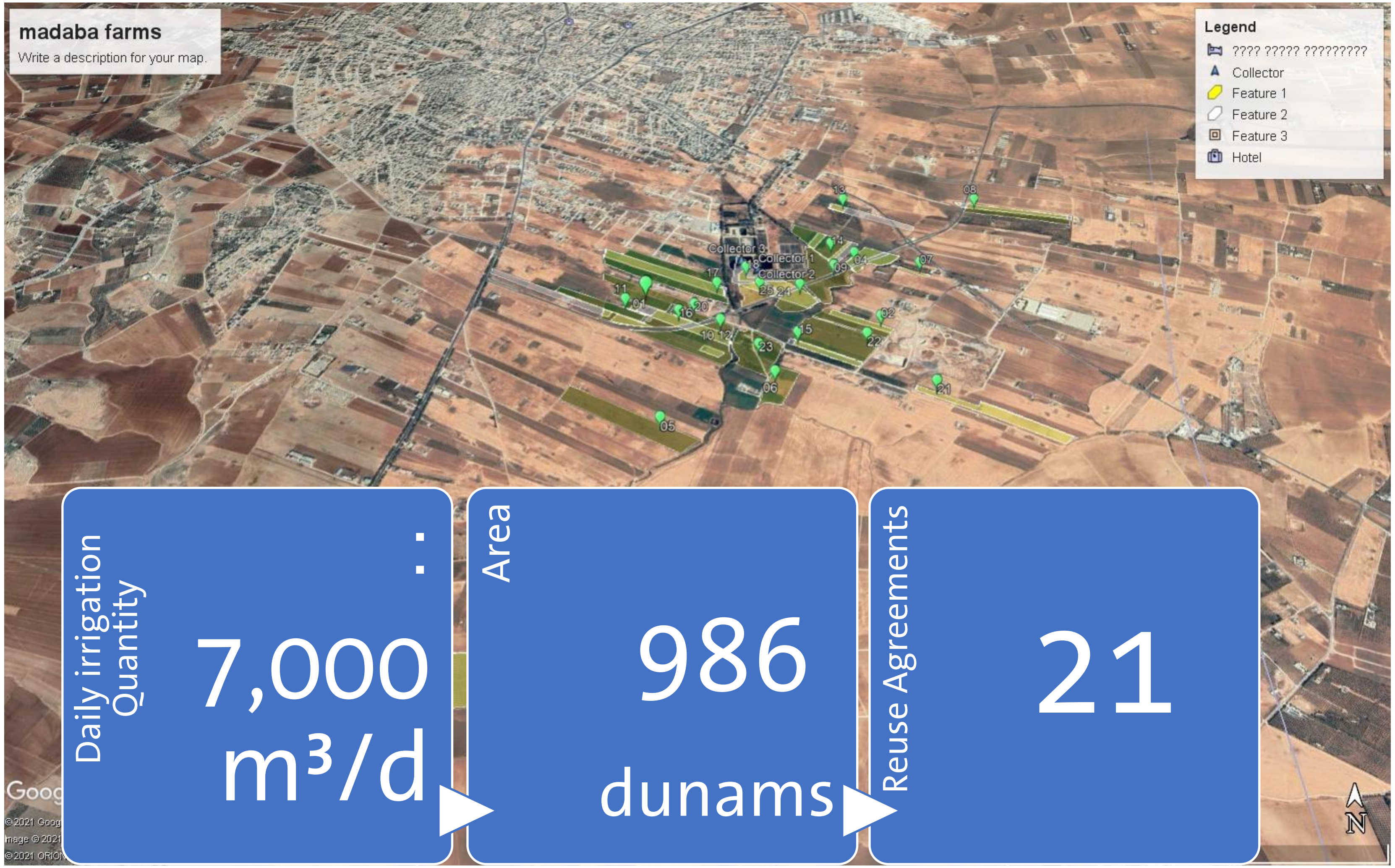
Daily Maximum Wastewater Flow	7,600 m^3/day
Water Treatment	Extended Aeration Activated sludge
Sludge Treatment	Gravity Thickening (Drying Bed)
Treated Water Reuse	Re-use for Agriculture (field crops)

Parameter	Raw wastewater	Design	Reference (JS893/2006) Category 3-C
BOD5	950	50	300
COD		150	500
TSS	1000	50	300
pH		7-9	6-9
T-N	150	50	100
PO4-P	40	15	30

Madaba WWTP - Plant Layout (Process)



Madaba WWTP – Reuse of treated wastewater



Daily irrigation Quantity: **7,000 m^3/d**

Area: **986 dunams**

Reuse Agreements: **21**

1 dunam is 1,000 m^2.

Madaba WWTP - challenges

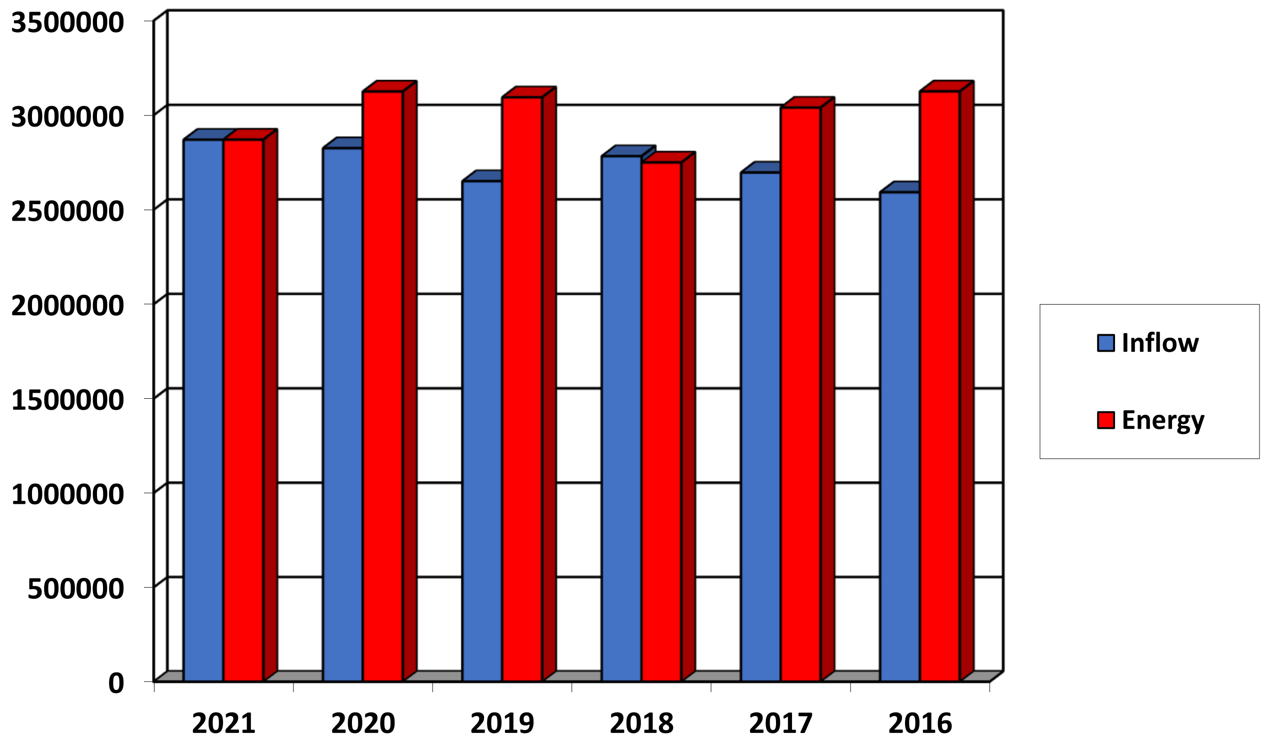
Since 2018, the **daily amount of incoming wastewater exceeded the design capacity** of 7,600 cubic meters per day and is still growing, adversely affecting the quality of treated water and the operational efficiency of the plant and posing a major challenge to the sustainable operation and maintenance of the plant (mechanical and electrical facilities and equipment over 20 years of age).

High demand of energy required for operation of the WWTP
(50 % of the total cost of treatment.)

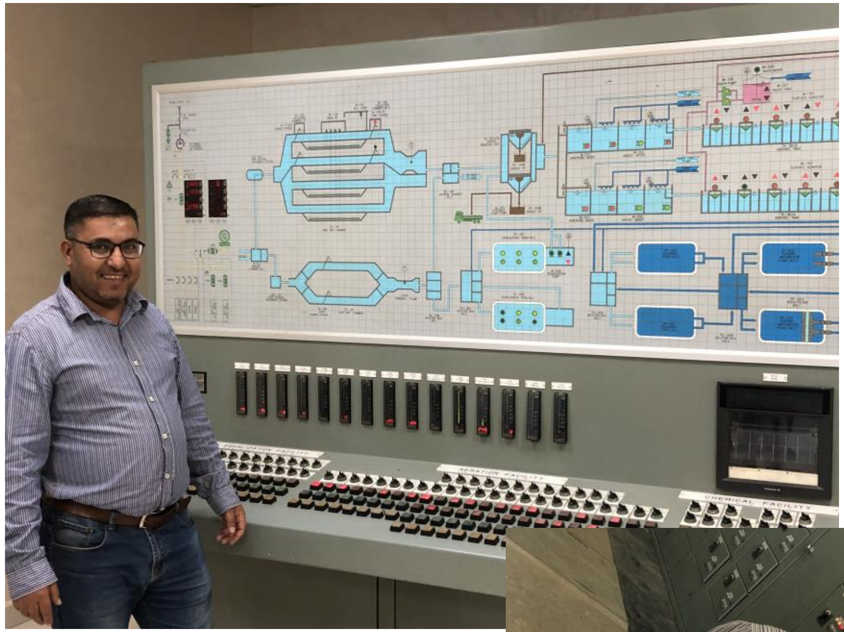
2019	2020	2021
7,648 m^3/d	7,720 m^3/d	7,870 m^3/d

Madaba WWTP – energy consumption

Year	Inflow (m^3)	Energy (kWh)	kWh/m^3
2021	2,870,401	2,870,673	**1.00**
2020	2,825,638	3,125,263	**1.11**
2019	2,651,250	3,094,576	**1.17**
2018	2,783,308	2,750,040	**1.00**
2017	2,696,620	3,040,060	**1.12**
2016	2,592,368	3,126,030	**1.21**



On site Madaba WWTP – energy analysis




What has been done?

- → Energy check
- → List of aggregates
  - → Classification
  - → Nominal values
  - → Annual Operating hours
  - → Measured values
  - → Real consumption
  - → Calculation of ideal values (not all done yet)
- → Comparison real/ideal values (not all done yet)
- → Saving opportunities (not all done yet)

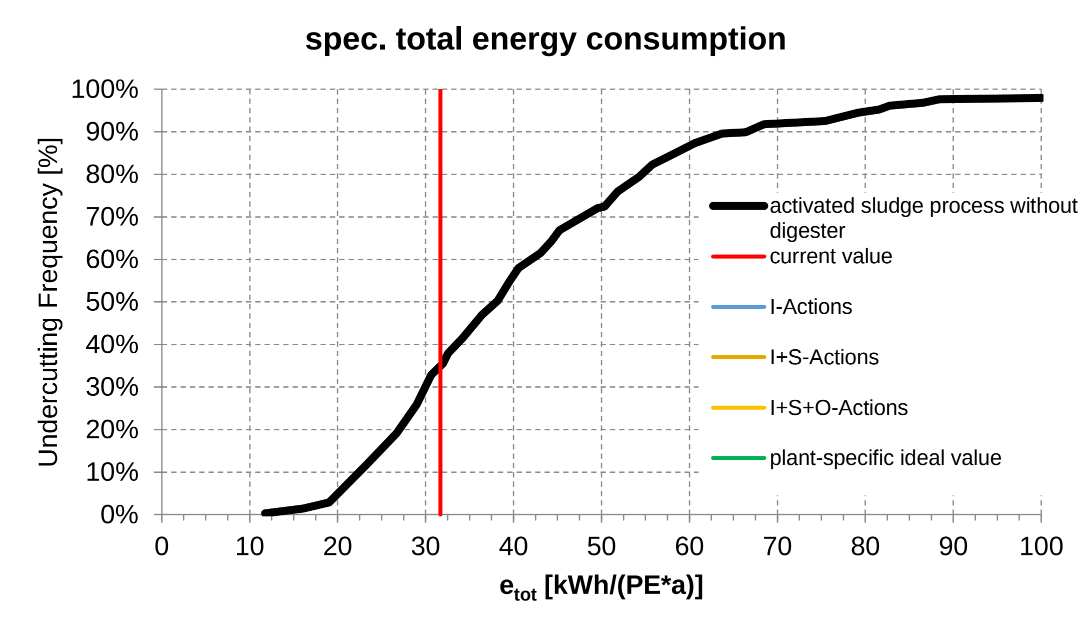
Energy check Madaba WWTP

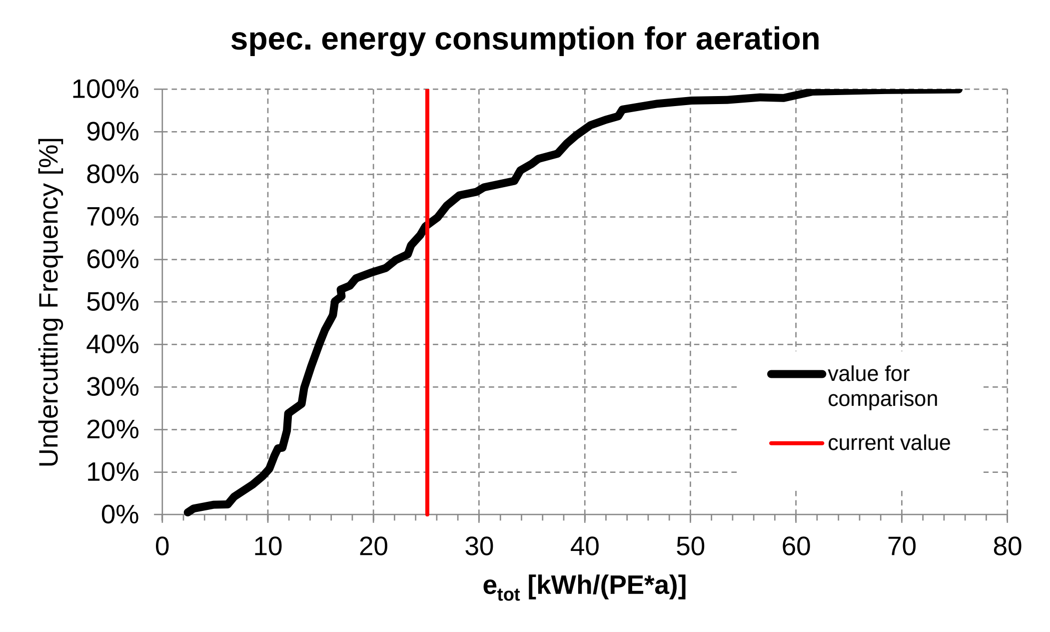
energy check

WWTP **Madaba, Jordan** GK5

1. Basic data type of plant: **activated sludge process without digester**

population equivalent related to 120gCOD/(PE*d) [inlet of WWTP]	PE_{COD}	103.502	PE	
total energy consumption (electrical)	E_{total}	3.277.128	kWh/a	9 months in 2022 and calculated for 12 months with higher consumption (aerators)
electrical energy consumption of the aeration in biological reactor	E_{aer}	2.600.000	kWh/a	roughly calculated for 6 months with 5 aerators on high level, 6 months with 8 aerators





List of aggregates Madaba WWTP

number of aggregates	49
in simulation	0
real consumption	3592633 kWh/a = 34,71 kWh/(EW*a)
ideal consumption	14490 kWh/a = 0,14 kWh/(EW*a)
percentage of registration	109,6%

substitutional values:	
cos phi	0,78
voltage	395 Volt

aggregate			group	classification			nominal values	nominal values				measured values	measured values					consumption	consumption				action / optimisation		action	comment
Nr.	facility identifier (Nr.)	name/description of aggregate		main group	side group	var x		volt [V]	ampere [A]	cos phi [-]	power [kW]		fc x	volt [V]	ampere [A]	power [kW]	power calculated [kW]		operating hours per year [h/a]	real energy consumption [kWh/a]	ideal energy consumption [kWh/a]	target/actual consumption ratio [%]		savings potential [kWh/a]	number of action	
1	M-102A	Fine Screen		mechanical treatment	screen			400	3,00		0,75			395	1,6		0,9		8140	7.326	7.245	101		81		
2	M-102B	Fine Screen		mechanical treatment	screen			400	3,00		0,75			395	1,6		0,9		8140	7.326	7.245	101		81		
3	M-206 A	Equalization pump		other	general			400	25,00		7,50			395	15,7		8,4		2300	19.320						

→ Every aggregate is listed, classified and the nominal values so as the voltage are written down.

→ The current ist measured for every running aggregate.

→ Operating hours and some other values had to be estimated in this case, because not every value is actually recorded. With all those informations, the real energy consumption can be calculated.

- Percentage of registration not so precise, but in a normal zone around 90-110%
- It is yet possible to see, where most of the energy is used.

Calculation of ideal values

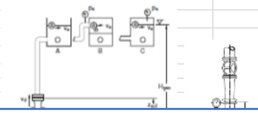
Screen				
No. in aggregate list	1	Bezeichnung: Fine Screen - M-102A		
Specific energy demand	0.07	kW/m³	Remark:	
PE (COD120)	103		7,245	kWh/a
No. in aggregate list	2			
Specific energy demand	0.07	kW/m³	Remark:	

spez. Energieverbr. [kWh/(EW*a)]
0,05 - 0,10 kWh/(EW*a)

25 Inner Circulation Pump - M-203 A

Target value				
Selection (x)				Efficiency Pump + Motor
	Screw trough pumps	Raw wastewater		0,50 - 0,60
		Return sludge		0,60 - 0,70
		Internal circuit		
	Centrifugal pump	Raw wastewater	Vortex wheel	0,45 - 0,55
			Single-channel wheel	0,50 - 0,60
x	Centrifugal pump	Return sludge Internal circuit Outlet (filter feed)	Multi-channel wheel	0,65 - 0,75
			Spiral wheel	0,65 - 0,75
	Propeller pump Tubular casing pump	Internal circuit		0,65 - 0,80
	Eccentric screw pump	Sludge		0,50 - 0,65
Selected target value				0.70

Förderhöhe:



via theoretical values:

$H_{geo.}$	4.00	m
H_V	2.00	m
H_A	6.00	m

Radtke, Nina:
6 m are from documentation

via measurement:

$P_{Suction\ side}$ bar

Delivery rate:			Operating hours	
Annual flow rate		m³/a	8,240	h/a
Daily flow rate	11520	m³/d		h/d
Hourly flow rate	480	m³/h		
Delivery rate:		m³/h	8240	h/a

Falsche Eingabe

Summary for parameters to calculate the ideal value in the aggregate list:

Delivery head [m]	Delivery rate: [m³/h]	Operating hours [h/a]	Efficiency [-]	Ideal consumption [kWh/a]	
6.00	480	8240	0.70	91535	<= Link

Remarks:

Mixer/Agitator				
No. in aggregate list	5	Bezeichnung: Anaerobic Mixer - M - 203 A		
Circulation volume	499	m³	Remark:	
Specific energy demand	3.5	W/m³		
Number of agitators per tank				
Operating hours	8		14,397	kWh/a
No. in aggregate list	6	3 B		
Circulation volume				
Specific energy demand				
Number of agitators per tank				
Operating hours	8		14,397	kWh/a
No. in aggregate list	7			
Circulation volume	499	m³	Remark:	

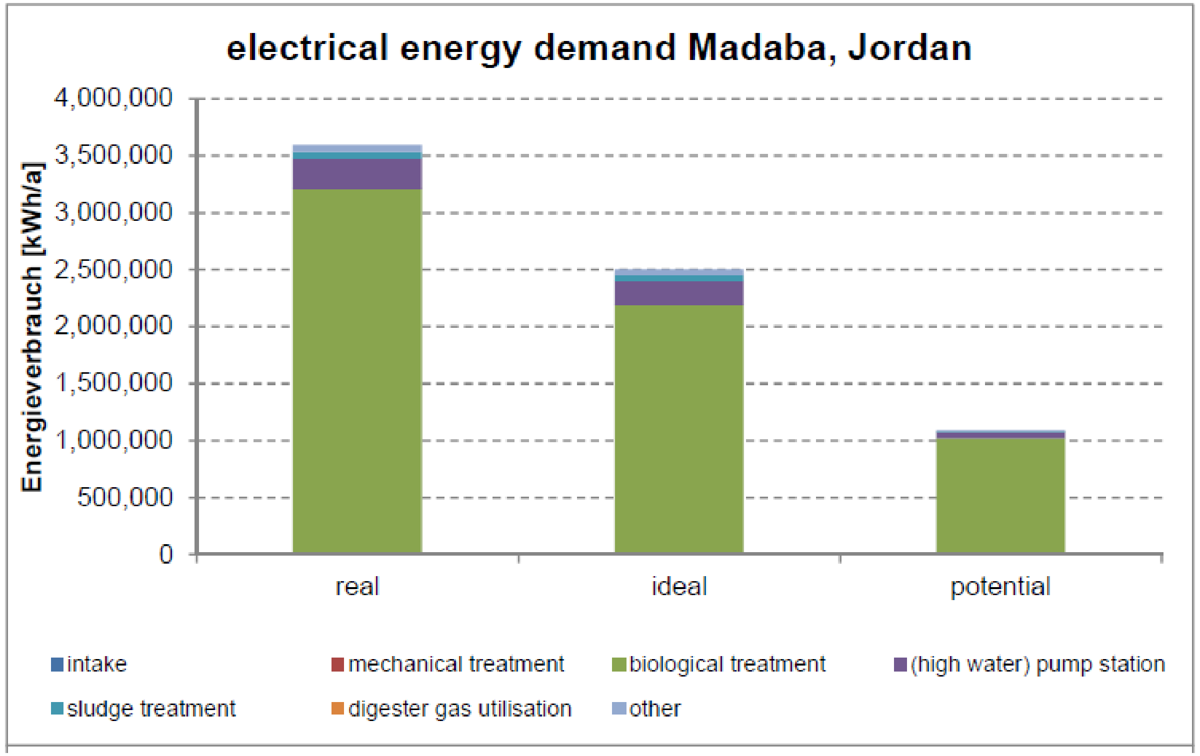
spezifische Energieverbräuche
4,0-2,5 für V 200-500m³
2,5-2,0 für V 500-1000m³
1,5-2,0 für V 1000-2000m³
1,5 für V >2000m³

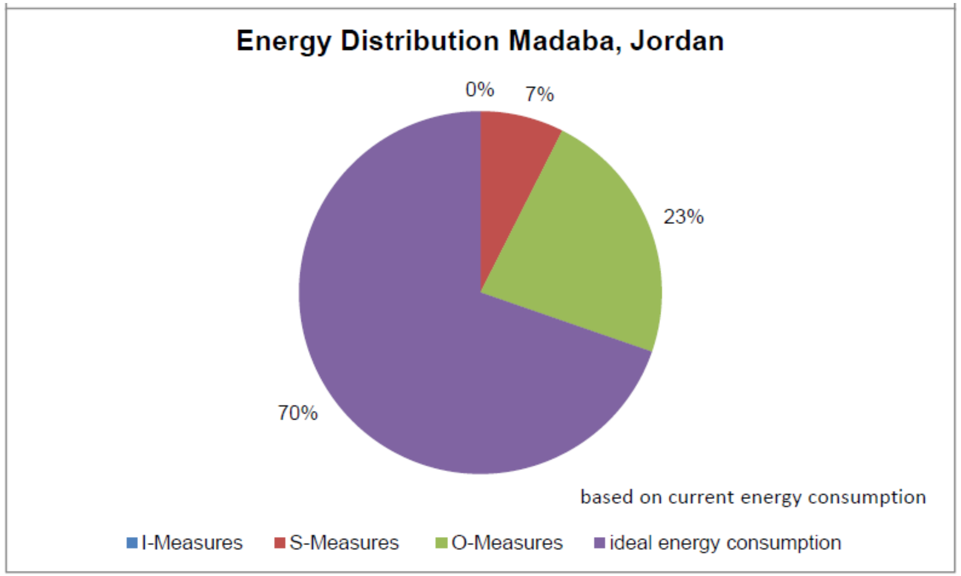
Comparison of expected energy and real energy consumption

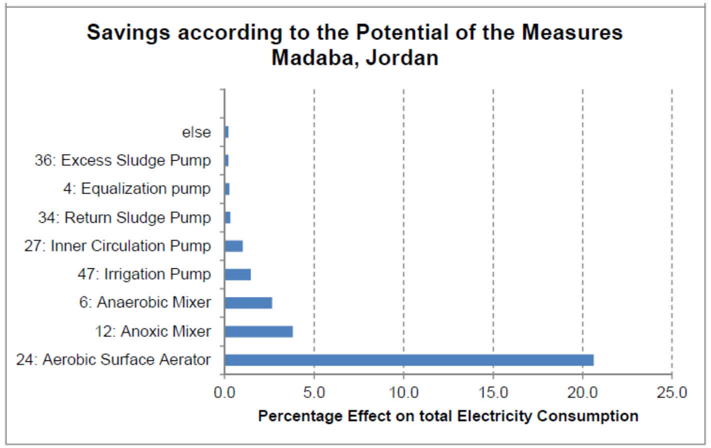
main group	side group	energy consumption		proportion of total consumption	specific ideal value for this plant		real / specific ideal value	savings potential		comments
		kWh/a	kWh/(PE·a)	%	kWh/a	kWh/(PE·a)	%	kWh/a	kWh/(PE·a)	
intake	general	0	0.0	0.0%	0	0.0	0.0%	0	0.0	
	pump station	0	0.0	0.0%	0	0.0	0.0%	0	0.0	
	total	**0**	**0.0**	**0.0%**	**0**	**0.0**	**0.0%**	**0**	**0.0**	
mechanical treatment	general	0	0.0	0.0%	0	0.0	0.0%	0	0.0	
	screen	14,652	0.1	0.4%	14,490	0.1	101.1%	162	0.0	
	grit/sand chamber	0	0.0	0.0%	0	0.0	0.0%	0	0.0	
	primary clarifier	0	0.0	0.0%	0	0.0	0.0%	0	0.0	
	total	**14,652**	**0.1**	**0.4%**	**14,490**	**0.1**	**101.1%**	**162**	**0.0**	
biological treatment	bio-P-removal	123,600	1.2	3.8%	28,794	0.3	429.3%	94,806	0.9	
	denitrification	179,632	1.7	5.5%	43,191	0.4	415.9%	136,441	1.3	
	nitrification	2,541,216	24.6	77.5%	1,800,000	17.4	141.2%	741,216	7.2	
	recirculation	181,812	1.8	5.5%	145,300	1.4	125.1%	36,512	0.4	
	returned activated sludge	141,728	1.4	4.3%	130,000	1.3	109.0%	11,728	0.1	not final
	secondary settlement tank	25,544	0.2	0.8%	25,544	0.2	100.0%	0	0.0	
	total	**3,193,532**	**30.9**	**97.4%**	**2,172,829**	**21.0**	**147.0%**	**1,020,703**	**9.9**	
(high water) pump station	general	261,589	2.5	8.0%	209,271	2.0	125.0%	52,318	0.5	not final
sludge treatment	primary sludge	0	0.0	0.0%	0	0.0	0.0%	0	0.0	
	wasted activated sludge	61,900	0.6	1.9%	55,000	0.5	112.5%	6,900	0.1	not final
	digested sludge	0	0.0	0.0%	0	0.0	0.0%	0	0.0	
	total	**61,900**	**0.6**	**1.9%**	**55,000**	**0.5**	**112.5%**	**6,900**	**0.1**	
gas treatment	general	0	0.0	0.0%	0	0.0	0.0%	0	0.0	
other	general	**60,960**	**0.6**	**1.9%**	**49,881**	**0.5**	**122.2%**	**11,079**	**0.1**	not final
total according to list of aggregates		**3,592,633**	**34.7**	**109.6%**	**2,501,471**	**24.2**	**143.6%**	**1,091,162**	**10.5**	
real consumtion according to electrical bill		3,277,128	31.7							

Comparison of expected energy and real energy consumption

Not final for some pumps etc.







Possibilities for optimisation (excerpt)

Madaba, Jordan

overview of detected possibilities during energy analysis

price for energy 0.105 JOD/kWh

Measure #	#	Designation	Description of measures	Type	Savings Potential kWh/a	Savings Potential kWh/PE	Savings Potential JOD/a
1	1	Fine Screen	Aggregate runs well. If a new one is needed, choose efficient aggregate.	O	162	0.00	17
2	4	Equalization pump	If a new one is needed, choose efficient aggregate. --> pressure loss is still needed!	O	8,870	0.09	931
3	6	Anaerobic Mixer	Aggregates are inefficient. More efficient mixers should be installed. For the two aggregates, savings around 10,000 JOD/a are realistic.	S	94,806	0.92	9,955
4	12	Anoxic Mixer	Only 3 of the 6 Anoxic Mixers are running. Changing these into more efficient aggregates would save around 15,000 JOD/a for energy, compared to the actual situation. If every anoxic basin would get mixed again to operate all 6 basins in a good way, the summed up savings would be even higher when all basins get more efficient mixers.	S	136,441	1.32	14,326

→ **There is already thought of necessary expansion of the plant because city is still growing fast… build it energy efficient from the start… Energy analysis might also be useful for these plans.**

Experiences from the energy analysis on Madaba WWTP

→The focus on process- and energy-optimization for WWTPs got bigger in the last few years, due to the fact that Jordan has limited water and energy ressources.

→Energy analysis seems to be a useful tool for Miyahuna. We found good options for energy savings on Madaba WWTP.

→Next step should be to implement some of the measures found in the analysis and to see the results.

→There are not many differences between doing the analysis in Germany or in Jordan. Only surface aeration and no measurement of operational hours were a bit different.

→It is much better to do an analysis like that in direct peer-to-peer-contact and on site. Only meeting each other online and reading the set of rules would not have brought the same good results! We experienced this, because the time of the Covid-pandemic (only online meetings) was not as effective as the visits.

Discussion/questions?

Thanks for your attention

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