# Present and planned activities in Sweden for improving the efficiency and communiction of water utilities

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# The VASS system is the base

- VASS is the web-based database of the Swedish Water Works Assn. It has been operative Wastewater since 2003
- VASS is used for compilation of statistics of Swedish water utilities
- VASS is used for calculation of PI's for water utilities
- VASS can be used for special investigations
- Utilities can extract reports  on demand
- All data reported in VASS is open to all other utilities

# Activities

- Data collection and PI calculation on utility level – on going since 2003. Three ambition levels; level 1- 80 % participation, level 2 – 20 % participation, the demanding level 3 so far less than 5 % participation.
- Energy use of WWTP's (2005, 2008 and 2011) – 60% participation based on population
- Biogas production and use (every year since 2005). 100 % participation

# Activities cont

- Data collection and PI calculations for WWTP's Fully developed and tested at 24 plants. Will be implemented in 2013
- Data collection and calculation of index for a hygienically safe drinking water – under development
- Data collection and calculation of a sustainability index for water utilities – under development

# Operation and economy on utility level

- Collected data: context, assets, water production, wastewater load, resource consumption, water quality, effluent quality, sludge quality, operation & disturbances of water mains, sewers and storm sewers, cost of operation, investments and consumer fees
- Water balance is calculated
- PI's calculated for operation and maintenance of water mains, sewers and storm sewers and for cost of operation
- PI's for water works and WWTP's on utility level are not meaningful as most utilities have several works

# PI's for wastewater treatment

- Data collected: process configuration and other context data, connections and loadings, effluent loadings, sludge quality, consumption of resources, energy use and production, personnel, costs and incomes.
- Plausibility of collected data checked on line with help of mass balances and deviation from empirical data

# PI's for waste water treatment cont

- Most PI's calculated with connected population equivalents as base (possible also to have drinking water use or waste water volume treated as a base)
- Several PI's related to amount of pollutants removed e.g. mole chemicals/mole P, costs per kg of COD removed
- Non-monetary units preferred where possible e.g. manhours instead of personnel costs

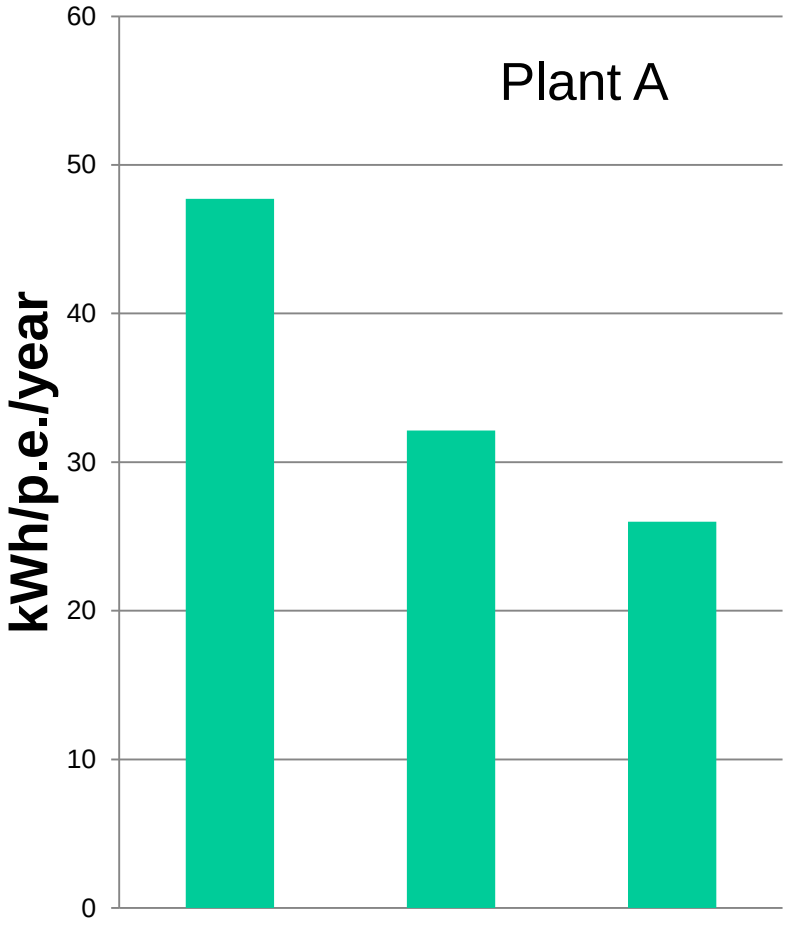
Balmér &Hellström 2012 Wat.Sci &Tech 56 pp 1304-10

Balmér & Hellström SVU-report 2011-15

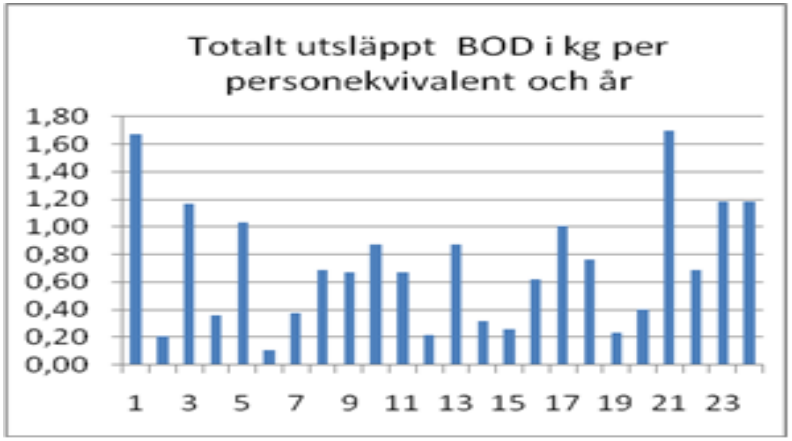
# Features

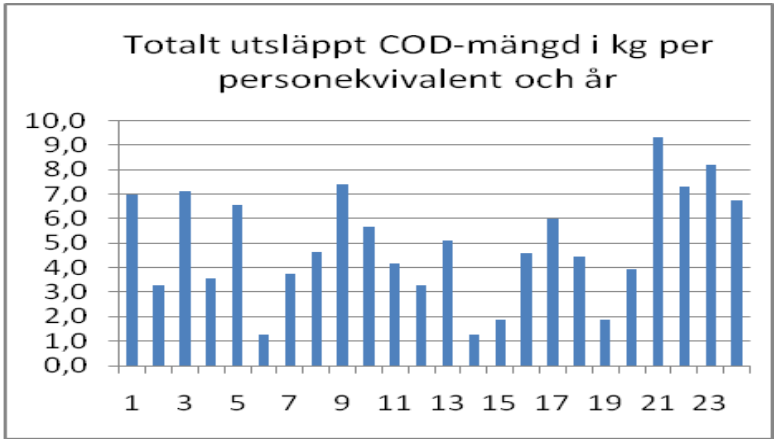
- Inclusion of explanatory factors in PI's
- The use of the exergy concept to compensate for differences in value of the different forms of energy

# PI compensation for influent pumps and nitrification



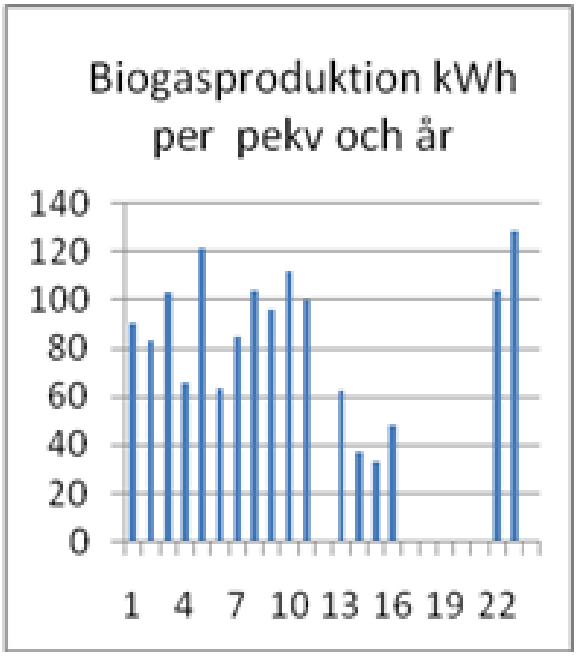

# PI examples – Discharges of BOD, COD, phosphorus, and nitrogen per pop equivalent and year

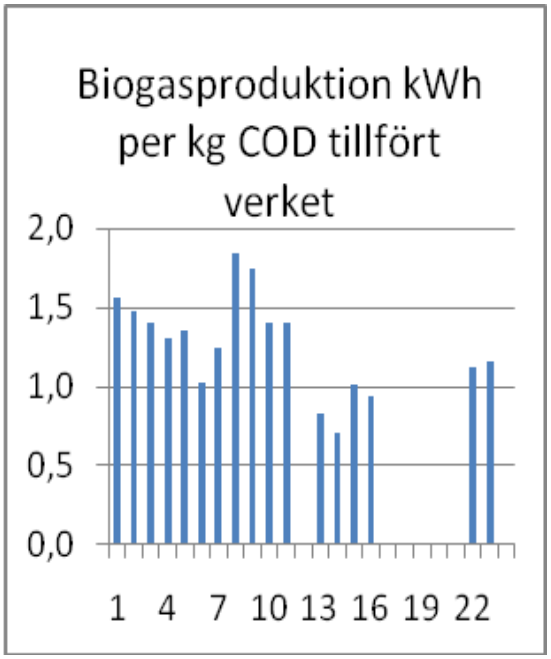


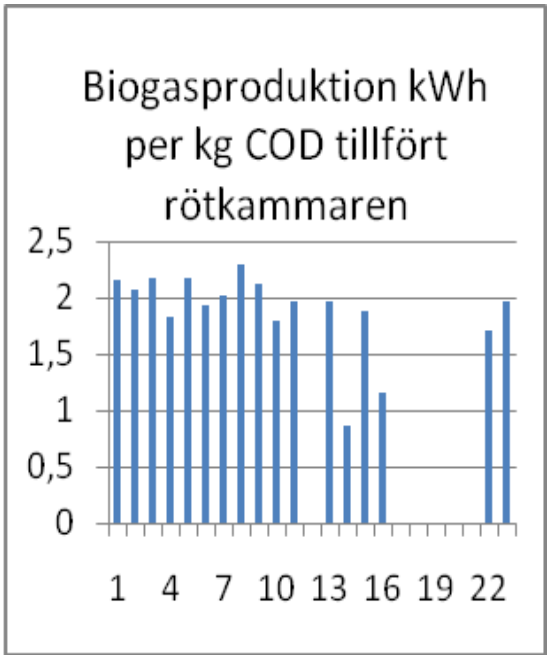





# PI examples – Biogas production per population equivalent and year, per kg of COD supplied to the WWTP and per kg of COD supplied to WWTP digesters



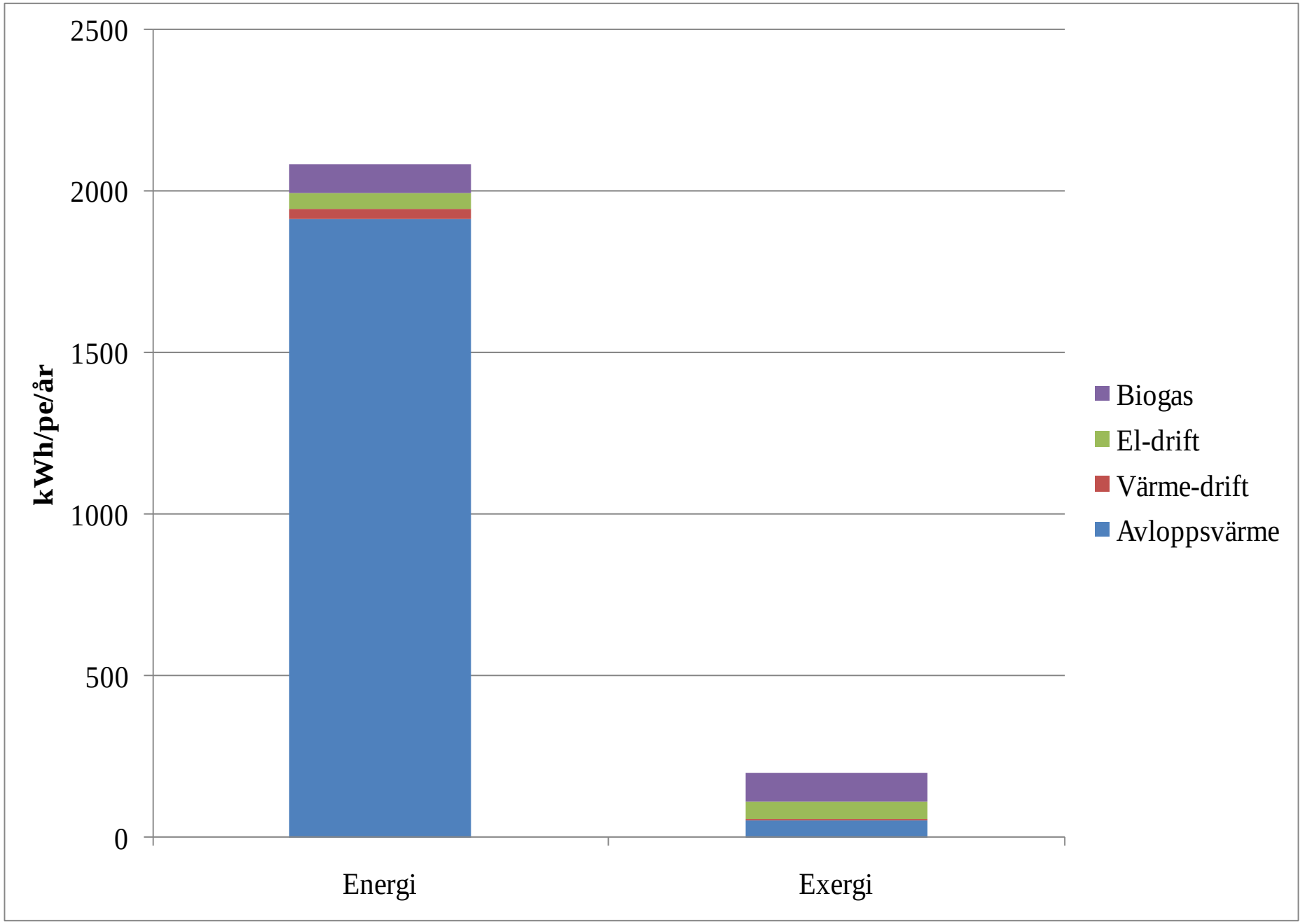



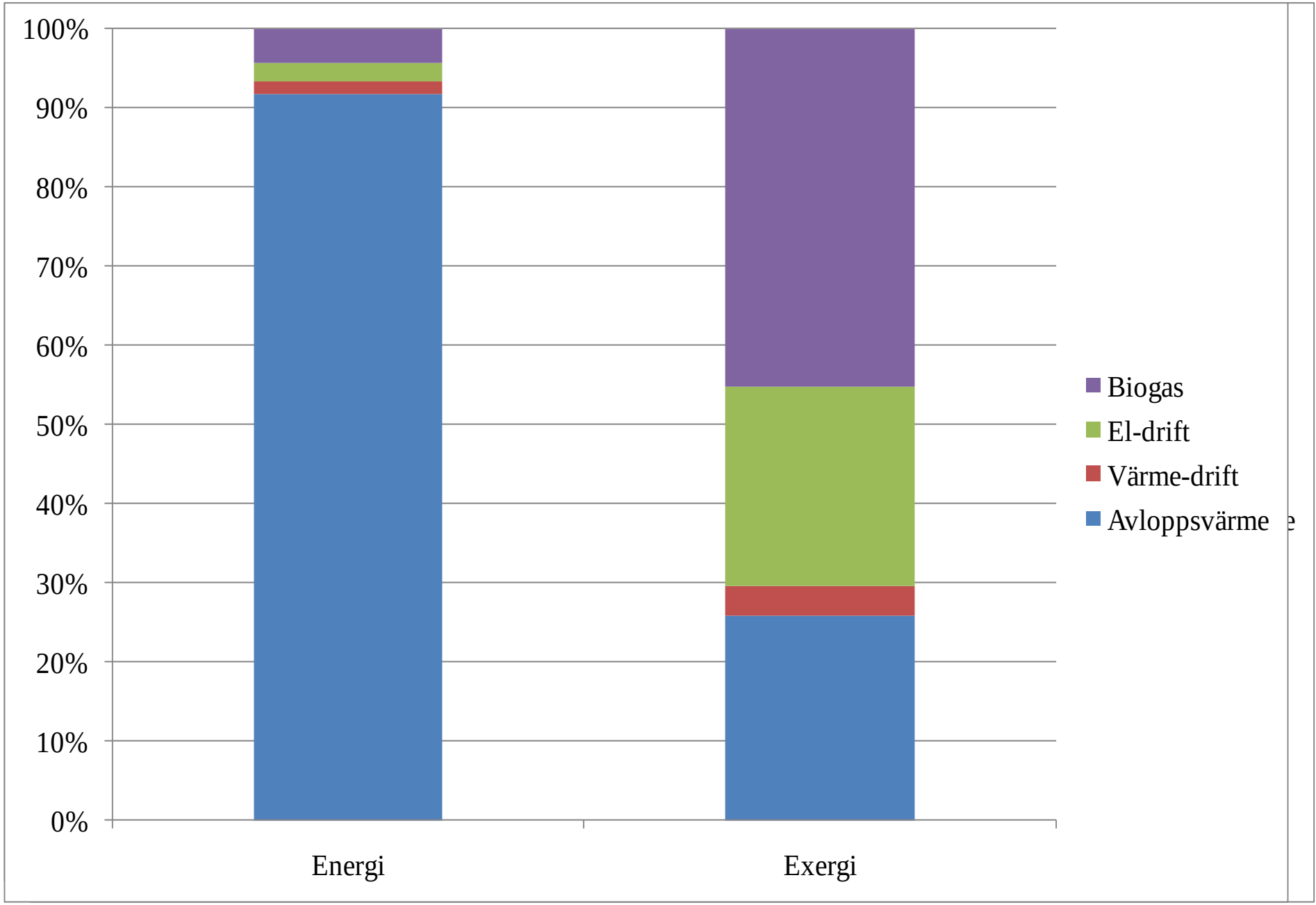
# Energy - Exergy

- Differences forms of energy have different value – electricity can be transformed to mechanical work or to heat while hot water has a limited use
- The exergy concept is a way to handle differences in value
- Exergy can be explained as the ability to perform work

# Exergy = Energy * quality factor

| **Source of energy** | **Exergy/Energy (%)** |
|---|---|
| Electricity | 100 |
| Gas | 100 |
| Steam (200 °C) | ~70 |
| District heating | ~30 |
| Waste heat (15 °C) | < 5 |


2500
2000
1500
1000
500
0
kWh/pe/år
Energi
Exergi
Biogas
El-drift
Värme-drift
Avloppsvärme


100%
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Värme-drift
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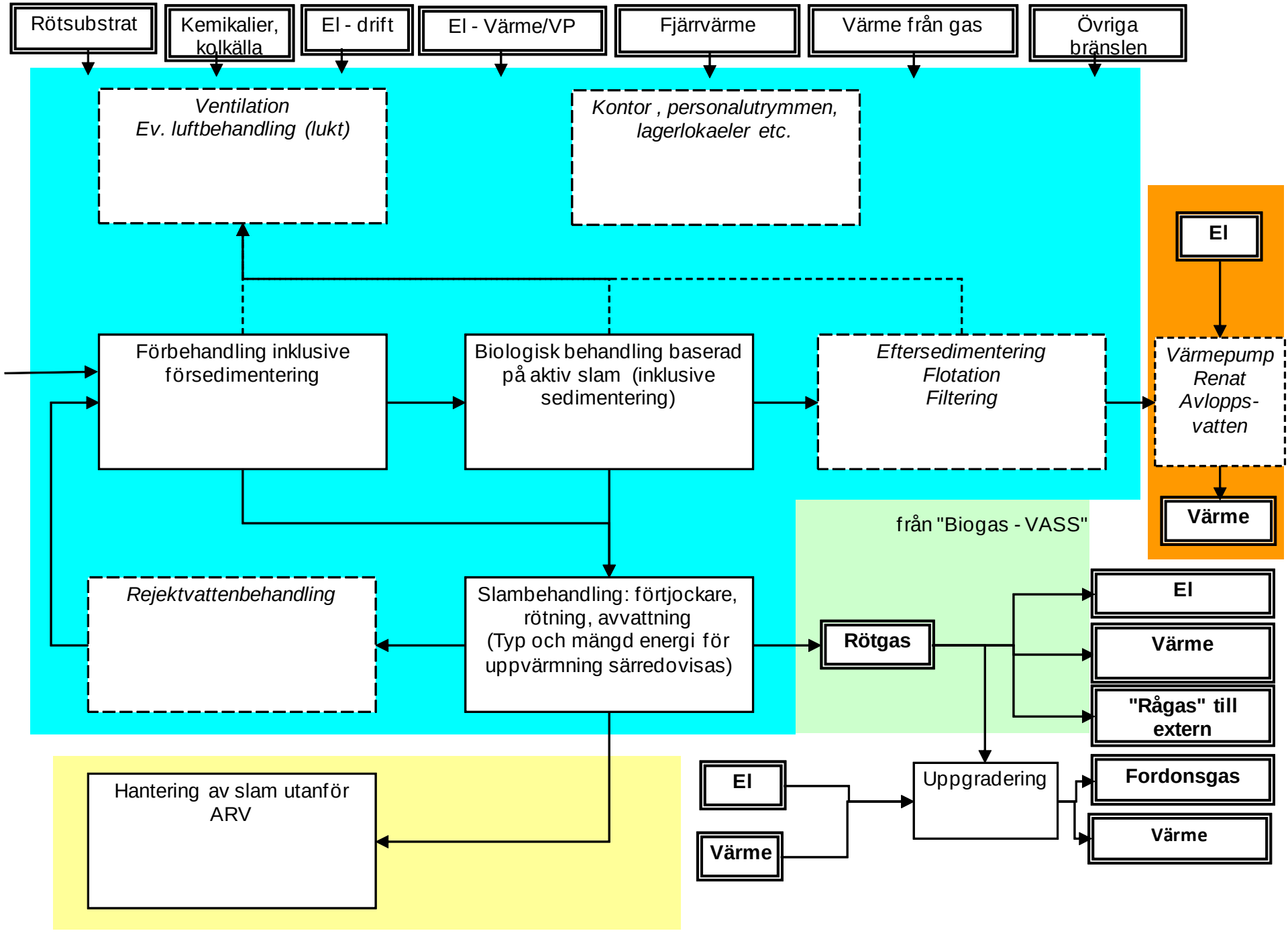
Rötsubstrat
Kemikalier, kolkälla
El - drift
El - Värme/VP
Fjärrvärme
Värme från gas
Övriga bränslen
Ventilation
Ev. luftbehandling (lukt)
Kontor , personalutrymmen, lagerlokaeler etc.
El
Förbehandling inklusive försedimentering
Biologisk behandling baserad på aktiv slam (inklusive sedimentering)
Eftersedimentering
Flotation
Filtering
Värmepump
Renat
Avlopps-
vatten
Värme
från "Biogas - VASS"
Rejektvattenbehandling
Slambehandling: förtjockare, rötning, avvattning
(Typ och mängd energi för uppvärmning särredovisas)
Rötgas
El
Värme
"Rågas" till extern
Hantering av slam utanför ARV
El
Värme
Uppgradering
Fordonsgas
Värme

# Exergy index

- $Ex_{eff} = Ex_{out}/(Ex_{sub} + Ex_{oper})$
- $Ex_{OCP} = (Ex_{sub} + Ex_{oper} - Ex_{out})/(OCP_{rem})$
- $Ex_{pe} = (Ex_{sub} + Ex_{oper} - Ex_{out})/\text{number conn}$

$Ex_{out}$ = exported energy and nutrients utilized

$Ex_{sub}$ = energy in influent organics and external organics received for digestion

$Ex_{oper}$ = exergy used in WWTP operation

OCP = Oxygen Consumption Potential

# Practioner's aspect on exergy

- Gas to CHP – 33 % electricity, 50 % hot water - exergy/energy approx 50 %
- Gas to upgrading – exergy/energy approx 95 % - but vehicle engine has an efficiency of approx 25 %
- Should a factor  for exergy that can be used in practise be added?

# Safe drinking water (under development)

- Necessary log reductions of bacteria, viruses and parasites is a function of raw water quality and number of populations served
- Log reduction achieved is a function of water works treatment processes except disinfection
- Log reductions by disinfection is a function of disinfection method, Ct, temperature and pH
- log reductions in water works and disinfection are added and should be > necessary log reduction

# Safe drinking water, cont

- Other factors will be included in the safe drinking water index as physical-chemical water quality and reliability of delivery to consumer

# A sustainability index for utilities (under development)

- Possibilities to identify strength and weaknesses of the utility

- Evaluation of sustainability in a short and long time perspective

- A tool for communication
  - Within the utility
  - Between the utility and the Board
  - Between the utility/Board and the public - the consumers

# Utility sustainability components