```
function [Ausgabe]=Abwaerme(on) %on is a placeholder just enter any number
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Definition

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%This script looks at six different scenarios:
%1. in scenario 1 the waste heat is equally recovered from liquid and air cooled data centers
with ideal ERF for district heating
%2. in scenario 2 the waste heat is mostly recovered by liquid cooled data centers, as they
have a higher potential in reuse with ideal ERF for district heating
%3. in scenario 3 the waste heat is equally recovered from liquid and air cooled data centers
with realistic ERF
%4. in scenario 4 the waste heat is mostly recovered by liquid cooled data centers, as they
have a higher potential in reuse with realistic ERF
%5. in scenario 5 the waste heat is equally recovered from liquid and air cooled data centers
with ideal ERF for reuse right at the data center e.g. heating of building
%6. in scenario 6 the waste heat is mostly recovered by liquid cooled data centers, as they
have a higher potential in reuse with ideal ERF for reuse right at the data center e.g.
heating of building
```

Data from research

```
E_total=20; %overall consumption by data centers in 2024 (in billion kWh/a) (Hintermann et al.
2022)
ERF_air=0.39; %max energy recovery factor of air cooled data centers in district heating
networks (Lerchner et al. 2023)
ERF_liquid=0.54; %max energy recovery factor of liquid cooled data centers in district heating
networks (Lerchner et al. 2023)
ERF_liquid_realistic=0.1; %realistic energy recovery factor of liquid cooled data centers
(Interview with Hintermann 2024)
ERF_air_realistic=0.05; %realistic energy recovery factor of air cooled data centers
(Interview with Hintermann 2024)
ERF_liquid_direct=0.7; %ideal energy recovery factor for of liquid cooled data centers, if
waste heat is directly reused (Lou et al 2019)
ERF_air_direct=0.5; %%ideal energy recovery factor for of air cooled data centers, if waste
heat is directly reused (assumption)
pc_wasteheat=0.9; %percantage of initial energy converted into waste heat (Lou et al. 2019)
PUE_enterprise=1.57; %PUE of enterprise data centers in 2024 (German Datacenter Association
2024)
pc_enterprise_it=0.31; %percentage of IT Power in Germany of enterprise data centers (German
Datacenter Association 2024)
pc_enterprise_WHR_24=0.15; %percentage of waste heat recovery in enterprise data centers in
2024 (German Datacenter Association 2024)
%pc_enterprise_WHR_26=0.23; %percentage of waste heat recovery in enterprise data centers in
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2026(German Datacenter Association 2024)
pc_enterprise_liquid_24=0.08; %percentage of liquid cooling in enterprise data centers in 2024
(German Datacenter Association 2024)
%pc_enterprise_liquid_26=0.10; %percentage of liquid cooling in enterprise data centers in
2026 (German Datacenter Association 2024)
PUE_colocation=1.3; %PUE of colocation data centers in 2024 (German Datacenter Association
2024)
pc_colocation_it=0.69; %percentage of IT Power in Germany of colocation data centers (German
Datacenter Association 2024)
pc_colocation_WHR_24=0.28; %percentage of waste heat recovery in colocation data centers in
2024 (German Datacenter Association 2024)
%pc_colocation_WHR_26=0.59; %percentage of waste heat recovery in colocation data centers in
2026 (German Datacenter Association 2024)
pc_colocation_liquid_24=0.31; %percentage of liquid cooling in colocation data centers in 2024
(German Datacenter Association 2024)
%pc_colocation_liquid_26=0.86; %percentage of liquid cooling in colocation data centers in
2026 (German Datacenter Association 2024)
Matrix=zeros(4,6);
```

Calculation

```
pc_enterprise_ec=(pc_enterprise_it*PUE_enterprise)/(pc_enterprise_it*PUE_enterprise+pc_colocat
ion_it*PUE_colocation); %percentage of energy consumption by enterprise data centers based on
IT power and PUE
pc_colocation_ec=(pc_colocation_it*PUE_colocation)/(pc_enterprise_it*PUE_enterprise+pc_colocat
ion_it*PUE_colocation); %percentage of energy consumption by colocation data centers based on
IT power and PUE
E_colocation=pc_colocation_ec*E_total; %amount of energy consumed by colocation data centers
E_enterprise=pc_enterprise_ec*E_total; %amount of energy consumed by enterprise data centers
totalwasteheat=E_total*pc_wasteheat; %total waste heat produced

for scenario=1:6
if scenario==1

wasteheat_colocation=pc_colocation_liquid_24*ERF_liquid*E_colocation+(1-pc_colocation_liquid_2
4)*ERF_air*E_colocation; %reusable waste heat produced by colocation data centers

wasteheat_enterprise=pc_enterprise_liquid_24*ERF_liquid*E_enterprise+(1-pc_enterprise_liquid_2
4)*ERF_air*E_enterprise; %reusable waste heat produced by enterprise data centers
        wasteheat=wasteheat_enterprise+wasteheat_colocation; %reusable waste heat produced
        wasteheat_reuse_colocation=wasteheat_colocation*pc_colocation_WHR_24; %waste heat
reused by colocation data centers
        wasteheat_reuse_enterprise=wasteheat_enterprise*pc_enterprise_WHR_24; %waste heat
reused by enterprise data centers
```

```
elseif scenario==2

wasteheat_colocation=pc_colocation_liquid_24*ERF_liquid*E_colocation+(1-pc_colocation_liquid_2
4)*ERF_air*E_colocation; %reusable waste heat produced by colocation data centers

wasteheat_enterprise=pc_enterprise_liquid_24*ERF_liquid*E_enterprise+(1-pc_enterprise_liquid_2
4)*ERF_air*E_enterprise; %reusable waste heat produced by enterprise data centers
        wasteheat=wasteheat_enterprise+wasteheat_colocation; %reusable waste heat produced
        if pc_colocation_liquid_24>pc_colocation_WHR_24
            wasteheat_reuse_colocation=ERF_liquid*pc_colocation_WHR_24*E_colocation; %waste
heat reused by colocation data centers in case all reused waste heat is in form of liquid
cooling
        else

wasteheat_reuse_colocation=ERF_air*(pc_colocation_WHR_24-pc_colocation_liquid_24)*E_colocation
+ERF_liquid*pc_colocation_WHR_24*E_colocation; %waste heat reused by colocation data centers
primarly by liquid cooled data centers, rest by air cooled.
        end
        if pc_enterprise_liquid_24>pc_enterprise_WHR_24
            wasteheat_reuse_enterprise=ERF_liquid*pc_enterprise_WHR_24*E_enterprise; %waste
heat reused by enterprise data centers in case all reused waste heat is in form of liquid
cooling
        else

wasteheat_reuse_enterprise=ERF_air*(pc_enterprise_WHR_24-pc_enterprise_liquid_24)*E_enterprise
+ERF_liquid*pc_enterprise_WHR_24*E_enterprise; %waste heat reused by enterprise data centers
primarly by liquid cooled data centers, rest by air cooled.
        end
elseif scenario==3

wasteheat_colocation=pc_colocation_liquid_24*ERF_liquid_realistic*E_colocation+(1-pc_colocatio
n_liquid_24)*ERF_air_realistic*E_colocation; %reusable waste heat produced by colocation data
centers

wasteheat_enterprise=pc_enterprise_liquid_24*ERF_liquid_realistic*E_enterprise+(1-pc_enterpris
e_liquid_24)*ERF_air_realistic*E_enterprise; %reusable waste heat produced by enterprise data
centers
        wasteheat=wasteheat_enterprise+wasteheat_colocation; %reusable waste heat produced
        wasteheat_reuse_colocation=wasteheat_colocation*pc_colocation_WHR_24; %waste heat
reused by colocation data centers
        wasteheat_reuse_enterprise=wasteheat_enterprise*pc_enterprise_WHR_24; %waste heat
reused by enterprise data centers

wasteheat_colocation=pc_colocation_liquid_24*ERF_liquid*E_colocation+(1-pc_colocation_liquid_2
4)*ERF_air*E_colocation; %reusable waste heat produced by colocation data centers
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```
wasteheat_enterprise=pc_enterprise_liquid_24*ERF_liquid*E_enterprise+(1-pc_enterprise_liquid_2
4)*ERF_air*E_enterprise; %reusable waste heat produced by enterprise data centers
        wasteheat=wasteheat_enterprise+wasteheat_colocation; %reusable waste heat produced
elseif scenario==4

wasteheat_colocation=pc_colocation_liquid_24*ERF_liquid_realistic*E_colocation+(1-pc_colocatio
n_liquid_24)*ERF_air_realistic*E_colocation; %reusable waste heat produced by colocation data
centers

wasteheat_enterprise=pc_enterprise_liquid_24*ERF_liquid_realistic*E_enterprise+(1-pc_enterpris
e_liquid_24)*ERF_air_realistic*E_enterprise; %reusable waste heat produced by enterprise data
centers
        wasteheat=wasteheat_enterprise+wasteheat_colocation; %reusable waste heat produced
        if pc_colocation_liquid_24>pc_colocation_WHR_24
            wasteheat_reuse_colocation=ERF_liquid_realistic*pc_colocation_WHR_24*E_colocation;
%waste heat reused by colocation data centers in case all reused waste heat is in form of
liquid cooling
        else

wasteheat_reuse_colocation=ERF_air_realistic*(pc_colocation_WHR_24-pc_colocation_liquid_24)*E_
colocation+ERF_liquid_realistic*pc_colocation_WHR_24*E_colocation; %waste heat reused by
colocation data centers primarly by liquid cooled data centers, rest by air cooled.
        end
        if pc_enterprise_liquid_24>pc_enterprise_WHR_24
            wasteheat_reuse_enterprise=ERF_liquid_realistic*pc_enterprise_WHR_24*E_enterprise;
%waste heat reused by enterprise data centers in case all reused waste heat is in form of
liquid cooling
        else

wasteheat_reuse_enterprise=ERF_air_realistic*(pc_enterprise_WHR_24-pc_enterprise_liquid_24)*E_
enterprise+ERF_liquid_realistic*pc_enterprise_WHR_24*E_enterprise; %waste heat reused by
enterprise data centers primarly by liquid cooled data centers, rest by air cooled.
        end

wasteheat_colocation=pc_colocation_liquid_24*ERF_liquid*E_colocation+(1-pc_colocation_liquid_2
4)*ERF_air*E_colocation; %reusable waste heat produced by colocation data centers

wasteheat_enterprise=pc_enterprise_liquid_24*ERF_liquid*E_enterprise+(1-pc_enterprise_liquid_2
4)*ERF_air*E_enterprise; %reusable waste heat produced by enterprise data centers
        wasteheat=wasteheat_enterprise+wasteheat_colocation; %reusable waste heat produced
elseif scenario==5

wasteheat_colocation=pc_colocation_liquid_24*ERF_liquid_direct*E_colocation+(1-pc_colocation_l
iquid_24)*ERF_air_direct*E_colocation; %reusable waste heat produced by colocation data
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centers

wasteheat_enterprise=pc_enterprise_liquid_24*ERF_liquid_direct*E_enterprise+(1-pc_enterprise_l
iquid_24)*ERF_air_direct*E_enterprise; %reusable waste heat produced by enterprise data
centers
        wasteheat=wasteheat_enterprise+wasteheat_colocation; %reusable waste heat produced
        wasteheat_reuse_colocation=wasteheat_colocation*pc_colocation_WHR_24; %waste heat
reused by colocation data centers
        wasteheat_reuse_enterprise=wasteheat_enterprise*pc_enterprise_WHR_24; %waste heat
reused by enterprise data centers
elseif scenario==6

wasteheat_colocation=pc_colocation_liquid_24*ERF_liquid_direct*E_colocation+(1-pc_colocation_l
iquid_24)*ERF_air_direct*E_colocation; %reusable waste heat produced by colocation data
centers

wasteheat_enterprise=pc_enterprise_liquid_24*ERF_liquid_direct*E_enterprise+(1-pc_enterprise_l
iquid_24)*ERF_air_direct*E_enterprise; %reusable waste heat produced by enterprise data
centers
        wasteheat=wasteheat_enterprise+wasteheat_colocation; %reusable waste heat produced
        if pc_colocation_liquid_24>pc_colocation_WHR_24
            wasteheat_reuse_colocation=ERF_liquid_direct*pc_colocation_WHR_24*E_colocation;
%waste heat reused by colocation data centers in case all reused waste heat is in form of
liquid cooling
        else

wasteheat_reuse_colocation=ERF_air_direct*(pc_colocation_WHR_24-pc_colocation_liquid_24)*E_col
ocation+ERF_liquid_direct*pc_colocation_WHR_24*E_colocation; %waste heat reused by colocation
data centers primarly by liquid cooled data centers, rest by air cooled.
        end
        if pc_enterprise_liquid_24>pc_enterprise_WHR_24
            wasteheat_reuse_enterprise=ERF_liquid_direct*pc_enterprise_WHR_24*E_enterprise;
%waste heat reused by enterprise data centers in case all reused waste heat is in form of
liquid cooling
        else

wasteheat_reuse_enterprise=ERF_air_direct*(pc_enterprise_WHR_24-pc_enterprise_liquid_24)*E_ent
erprise+ERF_liquid_direct*pc_enterprise_WHR_24*E_enterprise; %waste heat reused by enterprise
data centers primarly by liquid cooled data centers, rest by air cooled.
        end
end
wasteheat_reuse=wasteheat_reuse_enterprise+wasteheat_reuse_colocation;
pc_wasteheat_reuse=wasteheat_reuse/totalwasteheat;
Matrix(1,scenario)=round(totalwasteheat,2);
Matrix(2,scenario)=round(wasteheat,2);
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```
Matrix(3,scenario)=round(wasteheat_reuse,2);
Matrix(4,scenario)=round(pc_wasteheat_reuse*100,2);
end
Ausgabe=table(Matrix(:,1),Matrix(:,2),Matrix(:,3),Matrix(:,4),Matrix(:,5),Matrix(:,6));
Ausgabe.Properties.VariableNames ={'Szenario 1','Szenario 2','Szenario 3','Szenario
4','Szenario 5','Szenario 6'};
Ausgabe.Properties.RowNames={'produced wasteheat (billion kWh)','reusable wasteheat (billion
kWh)','waste heat reused (billion kWh)', 'percantage of total waste heat reused (%)'};
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end
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