Comparison of different architectures of substations for Decentralised Solar District Heating System



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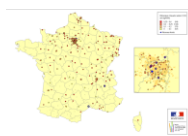
Introduction

- **Many district heating are in operation France**
  - **Growing interest for solar integration into the network**



- **DH mainly located in densely populated area**
  - **Almost impossible to have large field of collectors on ground**
  - **Building integration is more or less required**
  - **Decentralised solar system are necessary**

- **Different possibilities of connection to the network**
  - **Feed in : Return to return, return to flow ?**
  - **Local use of energy ? For DHW ? For space heating ?**

Introduction

- **This study has been done for the future Ecodistrict Villeneuve in Chambery**
  - 480 housings (12 buildings of 40 apartments)

- **District heating :**
  - New network will be build for the Ecodistrict
  - Low temperature district heating
  - Decentralised solar system on each building
  - Centralised storage
  - Auxiliary energy : from the existing high temperature district heating

Description of the architectures of the susbstations

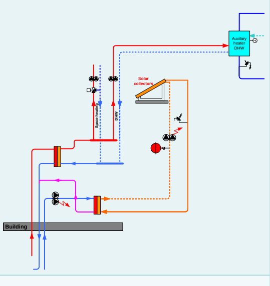
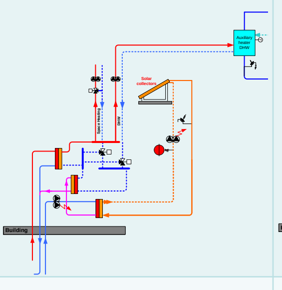
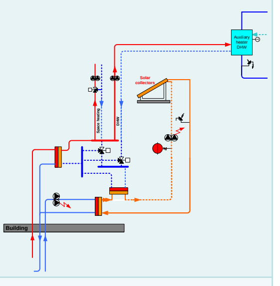
Architecture of the substations

- **9 different architectures of substations have been selected in collaboration with ITF (engineering conmapny)**

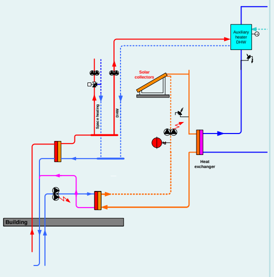
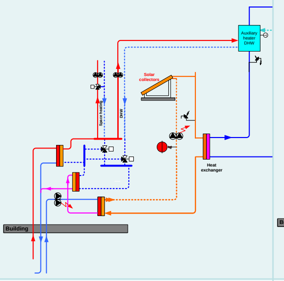
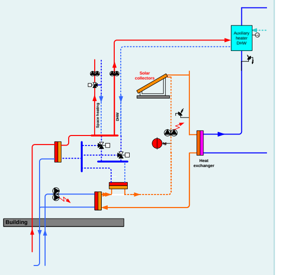
- **They are characterised by :**
  - **3 configurations for local use of solar energy for DHW preheating (E1-E2-E3)**
  - **3 configurations for local use of solar energy feed in the district heating (R1-R2-R3)**

- **Feed in principle : study focus only on return to return**

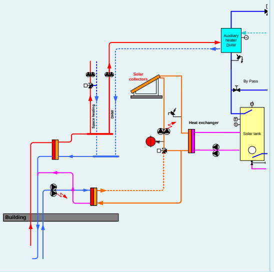
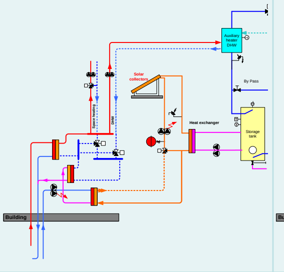
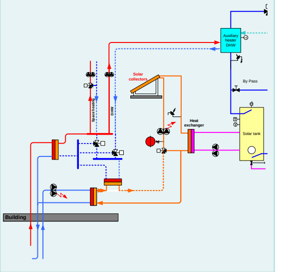
Architecture E1Rx

DHW preheating	No preheating (E1)		
Feed in district heating	No local use (R1)	Solar energy feed in the DH is used for preheating the DH return line (R2)	Solar energy is used to preheat return line of the DH after solar/DH heat exch. (R3)
Hydraulic scheme			
Characteristics	- Most basic solar installation - Needs 1 heat exchanger	- Needs 2 heat exchangers	- Solar energy is directly used from solar circuit to local circuit - Needs 2 heat exchangers

Architecture E2Rx

DHW preheating	Preheating with a DHW heat exchanger (E2)		
Feed in district heating	No local use (R1)	Solar energy feed in the DH is used for preheating the DH return line (R2)	Solar energy is used to preheat return line of the DH after solar/DH heat exch. (R3)
Hydraulic scheme			
Characteristics	- Use of solar for DHW only works for simultaneous DHW demand and solar ressources - Needs 2 heat exchanger	- Use of solar for DHW only works for simultaneous DHW demand and solar ressources - Needs 3 heat exchangers	- Use of solar for DHW only works for simultaneous DHW demand and solar ressources - Needs 3 heat exchangers

Architecture E3Rx

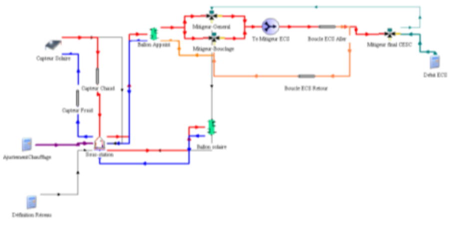
DHW preheating	Preheating with a DHW storage tank (E3)		
Feed in district heating	No local use (R1)	Solar energy feed in the DH is used for preheating the DH return line (R2)	Solar energy is used to preheat return line of the DH after solar/DH heat exch. (R3)
Hydraulic scheme			
Characteristics	- Local storage for solar energy - Needs 2 heat exchanger	- Local storage for solar energy - Needs 3 heat exchangers	- Local storage for solar energy - Needs 3 heat exchangers

Models and simulation

Models and simulation

- **Loads corresponds to a low consumption building of 40 apartments :**
  - **Space Heating : 25 kWh/m²**
  - **Domestic hot water : 20 kWh/m²**

- **All the hydraulic installation has been modelled with TRNSYS**
  - **A specific type has been developped**

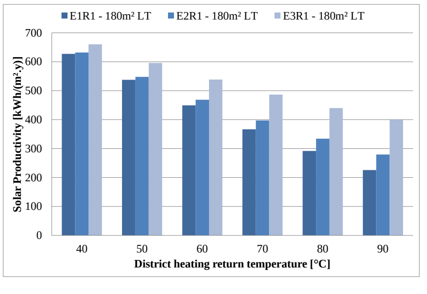


- **Weather station : Chambery (France)**

Results

Influence of the DH return temperature on the performance

- **Solar collector :**
  - Flat plate solar collector (LT) (η0=0.8, a1=3.5, a2=0.015)
  - 180m² (4.5m² per apartment)
- **District heating :**
  - Return temperature from 40 to 90° C
- **Influence for various configuration of DHW preheating**

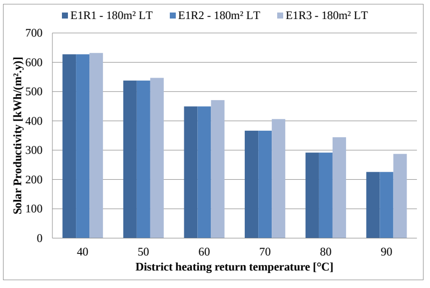


- Hydraulic layout has small influence for low DH return temperature
- With high DH return temperature, local storage of DHW has better performance

Influence of the DH return temperature on the performance

- **Solar collector :**
  - 180 m² flat plate solar collector
- **District heating :**
  - Return temperature from 40 to 90° C

- **Influence for various configuration of local use of solar feed in**



- R2 configuration where solar energy feed in is used for preheating the DH return line offers no improvement compared to R1. The DH network requires the solar collector working temperature
- With high DH return temperature, local use of solar feed in through the solar circuit has better performance

Influence of the DH return temperature on the performance

- **Difference of solar collector productivity between the solution ExRx compared to E1R1 for different DH return temperature**

DH return temp = 40°C			
Config	R1	R2	R3
E1	-	0%	1%
E2	1%	1%	1%
E3	5%	5%	6%

DH return temp = 50°C			
Config	R1	R2	R3
E1	-	0%	2%
E2	2%	2%	3%
E3	11%	11%	11%

DH return temp = 60°C			
Config	R1	R2	R3
E1	-	0%	5%
E2	4%	4%	7%
E3	20%	20%	20%

DH return temp = 70°C			
Config	R1	R2	R3
E1	-	0%	11%
E2	8%	8%	12%
E3	33%	33%	34%

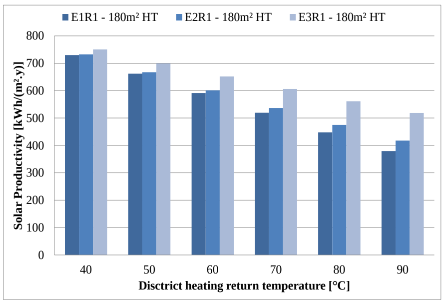
DH return temp = 80°C			
Config	R1	R2	R3
E1	-	0%	18%
E2	14%	14%	20%
E3	51%	51%	52%

DH return temp = 90°C			
Config	R1	R2	R3
E1	-	0%	27%
E2	24%	24%	31%
E3	77%	77%	79%

  - Performance of all configurations are affected by the DH return temperature
  - With high DH return temperature, local use of energy for DHW and/or space heating should be prefered

Influence of the type of solar collector on the performance

- **Solar collector :**
  - Double covered flat plate collector (HT) (η0=0.817, a1=2.2, a2=0.0135)
  - 180m² (4.5m² per apartment)
- **District heating :**
  - Return temperature from 40 to 90°C
- **Influence for various configuration of DHW preheating**



- With high DH return temperature, local storage of DHW has better performance
- Use of HT solar collector limit the effect of performance decrease for high DH return temperature

Influence of the type of solar collector on the performance

- **Difference of solar collector productivity between the solution ExR1 compared to E1R1 for different DH return temperature**
  - LT Solar collector

DH return temp	40°C	50°C	60°C	70°C	80°C	90°C
Config	R1	R1	R1	R1	R1	R1
E1	-	-	-	-	-	-
E2	1%	2%	4%	8%	14%	24%
E3	5%	11%	20%	33%	51%	77%

  - HT solar collector

DH return temp	40°C	50°C	60°C	70°C	80°C	90°C
Config	R1	R1	R1	R1	R1	R1
E1	-	-	-	-	-	-
E2	0%	1%	2%	3%	6%	10%
E3	3%	6%	10%	17%	25%	37%

- *Use of HT solar collector limit the effect of performance decrease for high DH return temperature*

Conclusions

Conclusions

- **DH return temperature has a real influence on the solar thermal collector productivity**
  - **Promote low operation temperature for DH**
  - **If not possible :**

    - *some configuration of substations can limit the performance degradation of solar systems : local use of energy has to be preferred for high DH return temperature*
    - *high temperature solar collectors can also limit the decrease of the solar performance. They also reduces the difference of performance between the different configurations of substations.*
- **The operation and the choice of a typology of substation cannot be limited at the level of the substation**
  - **think across the complete network, especially if :**

    - *the share of solar energy in the network is large : each substation may have an influence on each other*
    - *the temperature of the district heating is highly variable*

Conclusions

- **Extend the study for return to flow feed in**
  - **a more complete overview of substations for decentralised solar district heating systems**

- **Final choice of the substations :**
  - **Energetic performance of the system**
  - **But also the economic part**
    - *Studied substations are more or less complex with more or less components*
    - *Completed with an economic study in order to have the most efficient solar kWh*

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  - **ADEME through the Program of Renewable Energy Investments for the Future (Project Smart Grid Solaire Thermique)**
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Thanks for your attention !