Overview on systems for process heat applications

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Significance of industrial process heat demand

Note: EJ = exajoule.

Source: Solar Payback (2017), based on IEA statistics and calculations by IRENA.

Key message • Heat represents three-quarters of industrial energy demand worldwide, and half of it is of low to medium-high temperature.

Renewable Energy Technologies for Power Generation

Hydro

Solarthermal

Biomass

Tidal

Wave

Photovoltaic

Wind

Geothermal
Renewable Energy Technologies for Process Heat

Geothermal

Concentrating Solar

Biomass

Non-concentrating Solar
Collector technologies on the market (1/2)

**Flat plate**
- C: =1
- T: < 100°C
- P: ~ 1 kW – 10 MW
- Domestic hot water, space heating, process heat

**Evacuated tube**
- C: < 4
- T: < 150°C
- P: ~ 1 – 100 kW
- Domestic hot water, space heating, process heat
Collector technologies on the market (2/2)

Linear fresnel

C: < 100
T: < 500°C
P: ~ 0.1 – 1000 MW
Process heat,
Electricity generation
Polygeneration

Parabolic trough

C: < 100
T: < 500°C
P: ~ 0.1 – 1000 MW
Process heat,
Electricity generation
Polygeneration
Emerging options for high temperature applications

**Solar tower**

Open volumetric receiver

- Proven technology: hot air up to 680°C (solar tower plant Jülich, 10MW_th)

**Particle receiver**

- Ceramic particles as heat transfer and storage medium up to 1000°C
- 2.5 MW_th receiver under test
Near term markets

Low and medium temperature process heat demand by sector (Taibi 2010)

Challenges in Solar Process Heat

- Heat cannot be transported easily over long distances
  - Meteorological conditions at the site
  - Availability of suitable areas for collectors (ground, roof, facades)

- Solar field size (= investment cost) proportional to thermal power
  - Rational use of energy minimizes heat demand
  - Process optimization often more cost effective than solar energy

- Collector efficiency temperature dependent
  - Selection of suitable collector technology
  - Integration of solar heat at appropriate temperature

- Annual, daily and stochastic variations of radiation
  - Load management, heat storage or conventional back-up
  - Similar load and radiation profiles may increase solar share

- O&M effort for additional technology
  - Priority for O&M personnel: Efficient production
  - Fully automated solar operation
Direct steam supply to selected processes

- Optimized temperature level
- Separate solar heat system
- Steam distribution
- Condensate return
- Feedwater treatment
- Safety features
- Back-up Control
- Process demand profiles
- Storage requirements
Indirect steam supply via existing steam distribution

- Utilisation of existing infrastructure
  - Steam Distribution
  - Condensate return
  - Feedwater treatment
- Simple back-up control
- High security of supply
- Increase of potential solar share
- Improved solar capacity factor
- Reduced storage requirement
Solar Process Heat
RAM-Pharma, Amman, Jordan

- Direct steam generation in Fresnel collector field (394 m²)
- Start of operation: March 2015
- 160 °C
Solar Process Heat
RAM-Pharma, Amman, Jordan
Solar Process Heat
RAM-Pharma, Amman, Jordan

- 30.06.2016: High irradiation & High demand
- Symbiosis of fossil boiler and solar field works well
High pressure steam for co-generation

- Exploitation of exergy potential of concentrating collectors
- Added value from electricity production
  - Increased investment
  - Increased complexity
- Option: hybrid co-generation
Solar-aided cogeneration for Brazilian sugar cane industry

Background:
• Sugar and alcohol production from sugar cane is an important industry sector in Brazil
• Residual bagasse is used in biomass combined heat and power plants
• About 360 plants providing 6% of installed capacity
• Typical parameters:
  • 30 MW (20 MW own consumption, 10 MW into grid)
  • Live steam 67 bar / ~ 500 °C
• Operation during harvest season April – December

Aim:
• Extend operating time into off-season
• Improve capacity factor
Solar-aided cogeneration for Brazilian sugar cane industry

Concept idea

Source: UFSC
Pre-heating in foundries with induction furnaces to save electricity
Case study for foundry in Brazil, State of Sao Paulo

- Particle receiver technology
- Investment costs: 9.7 M€
- Payback time: 4 years (without subsidies and bank loans)
Small scale solar power ReelCoop (EU-funded)
Enit, Tunis, Tunisia

- Site status May 2016
Small scale solar power ReelCoop (EU-funded)
Enit, Tunis, Tunisia

- Direct steam generation 1000 m²
- ~500 kW\textsubscript{th} / 60 kW\textsubscript{el} Organic Rankine Cycle
- 170 °C / 8 bar
Cost estimate for solar process heat

- Assumptions:
  - Parabolic trough with evacuated absorber tube
  - Outlet temperature 140°C
  - Nominal thermal power: 10 MW<sub>th</sub>

- Lower boundary:
  - Specific solar field cost 240 €/m²
  - All solar heat can be used (process demand always higher than solar field output)
  - Heat cost at solar field outlet (no integration cost)

- Higher cost possible due to
  - Smaller solar field (higher specific cost)
  - Energy dumping due to lack of demand
  - Integration cost, balance of plant
Institute of Solar Research
Potential Support

• Feasibility studies
  • Concept development and evaluation
  • Technology recommendation

• Technology development / adaption
  • Increase local content (materials, labour)

• Planning, construction supervision, start-up of solar facilities
  • Consulting support for client
  • Liaison with technology suppliers

• Training

• Monitoring of operation
  • Feedback of practical experience
  • Future improvements
Thank you for your attention

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