Solar Energy for the Aluminium Industry's Transition into the Future

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Abstract

In many regions, apart from energy efficiency measures, solar energy utilization will be the way to reconcile future environmental and economic requirements of aluminum production. In the paper we present, analyze and compare options for solar energy utilization, namely concentrating solar-thermal (CSP) and photovoltaics (PV). The analysis is regarding cost, performance, decarbonization rate, i.e. reduction of attributable greenhouse gas emissions, and land requirements. The focus is on applications for solar thermal collectors, specifically on enclosed parabolic trough collectors providing heat at up to 430 °C, including configurations featuring integrated thermal energy storage. They are compared to systems using PV-trackers, again including systems featuring thermal energy storage. A cost comparison is performed using a 'Levelized Cost of Heat' calculation, performance is assessed using the publicly available tool 'Solar Advisory Model' plus a validated in-house model for solar-thermal technologies.

Keywords: Aluminium production, Solar energy, Concentrated solar power (CSP), Photovoltaics (PV), Decarbonization.

1. Introduction

Aluminium is required for most future technologies, from PV module frames to lightweight cars. At the same time its production is very energy intensive. Thus, the industry is exposed to financial and regulatory risks from high energy costs and increasing costs for GHG emission rights [1]. Transforming the aluminium industry to a low-carbon sector is the challenge being faced.

One obvious option at suitable locations is a transition to solar energy. Several technologies are available to generate heat and power, which differ regarding cost, generation characteristics, options to integrate energy storage, land requirement and more.

While some companies may prefer to diversify and enter the market of power and heat generation, others want to keep focus on their core business. For the latter, power or heat / steam purchase agreements with owners and operators of renewable energy facilities may be the preferred option.

In the paper an overview is given over selected options for renewable energy provision including business models available, with a focus on enclosed parabolic trough systems, as they are the most cost-efficient option in many cases today, and PV systems, as they are widespread and very modular.

There are two major technical options to convert solar radiation into useful energy for technical processes:

a) Photovoltaics (PV), i.e. the direct conversion of radiation energy into electricity [2]. Electricity can then be converted to heat, if required.

b) Solar-thermal systems, i.e. the conversion of radiation energy into thermal energy. Optionally, in a subsequent step, thermal energy can be converted into electric energy by using turbines and electric generators [3].

If electricity is required, direct conversion using PV has the benefit of simplicity. If thermal energy is required, solar-thermal systems have the advantage of significantly higher conversion efficiencies and as a result, lower cost of heat, as will be shown below.

Another differentiator is the possibility of integrating energy storage: Integrating thermal storage into (solar-)thermal systems is straightforward and cost-efficient, integrating electric energy storage into PV systems is very costly and currently only a feasible option if electricity is the eventually desired energy form.

In the following, the term ‘solar fraction’ will be used. It is defined as ‘energy provided using solar irradiation as energy source’ divided by ‘total energy demand’, considering one calendar year for both values. To give an example: Assuming a process requires 438 GWh per year (continuous demand of 50 MW x 8 760 h/year), and a solar system provides 110 GWh per year of that demand, the ‘solar fraction’ is 110 GWh / 438 GWh ≅ 0.25, or 25 %.

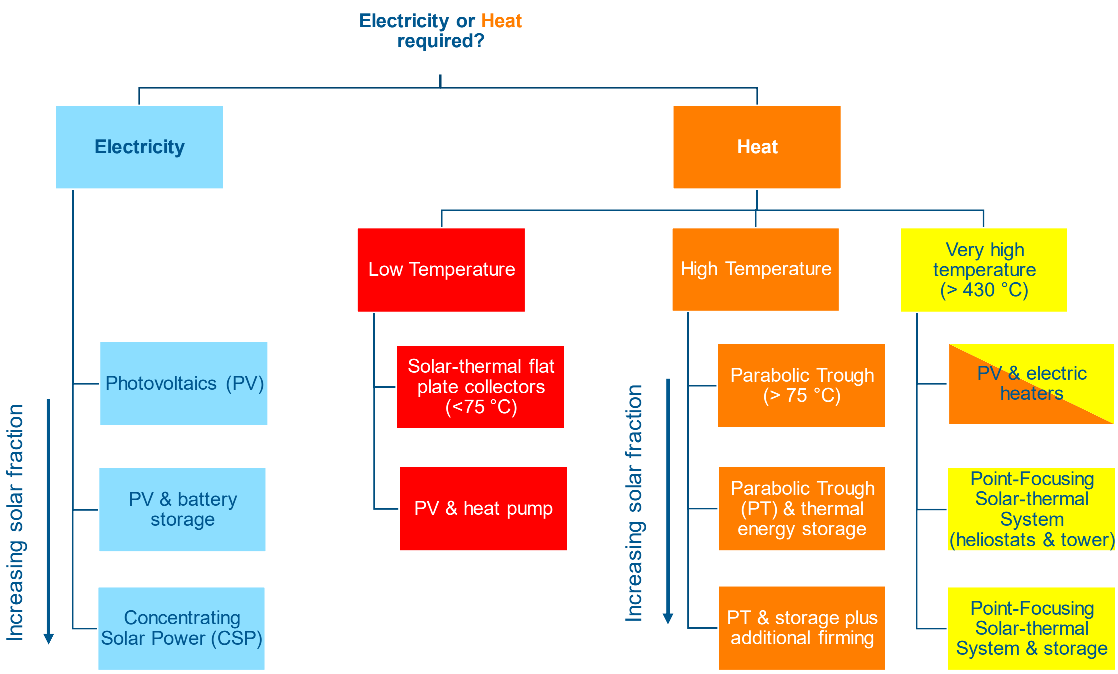

Figure 1. Selected options for provisioning of electricity or heat for industry.

Figure 1 gives an overview on options to provide electricity (left) or heat (right), with possible solar fraction increasing from top to bottom. This analysis focuses on high temperature heat (orange), i.e. systems employing parabolic troughs and/or PV and electric heaters with and without storage, respectively.

2. ‘Solarizing’ the Bayer Process

In the exemplary analysis, we will use the Bayer process for illustration.

5.2 Steam Purchase Agreement vs Self-operating the Solar System

Often companies prefer to focus on their core business. For them, 'heat (or steam) purchase agreements' with owners and operators of renewable energy facilities may be the preferred option.

For such clients, GlassPoint, the world leader and expert in designing, building and operating large-scale solar thermal systems, runs and operates the solar installations. The client only needs to sign a steam purchase agreement, hedging his risk of fossil fuel price increases while reducing the carbon footprint of his products. Should the client prefer to own and operate the solar-thermal system himself, GlassPoint is also ready to discuss and tailor this approach.

6. Summary and Outlook

The main findings are:

- Technologies are available enabling process heat decarbonization to a wide degree,
- For significant decarbonization rates, solar-thermal heat provision is more cost- and land-efficient than PV plus storage by factors of two and higher, respectively,
- Each site and each client is unique and therefore deserves a tailored solution. Tailored solutions can be designed and built from standardized proven building blocks.
- A 'heat purchase agreement' business model is available that caters client's needs.

7. References

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