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# Impact of guide wall geometry on the power output of a solar chimney power plant

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**Abstract**

This study investigated the impact from the geometry of guide walls (GWs) on the power output of a solar chimney power plant. Numerical simulations found a reduction in the mass flow rate after adding a guide wall in the system. The driving force and the velocity, however, showed a significant increase along the increasing altitude of GWs. The potential maximum power output was enlarged by 29.6% in a cylindrical-chimney system and by 6.3% in a divergent-chimney system compared to the system without guide walls. Based on the results, the GW height should be a primary criterion for designing GWs.


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*Keywords:* Solar chimney, Guide wall, Power output, CFD

## 1. Introduction

Solar chimney power plant (SCPP) is a system that converts solar thermal energy into electricity by generating a buoyant updraft inside a chimney to drive wind turbines. SCPP has advantages in its low cost in operation and its capability of providing clean energy without aggravating environmental pollution and intensifying climate change. It is believed that there is a high application potential of SCPP in developing countries that have large available lands and abundant solar insolation [1]. Recently, novel concepts has been proposed in which SCPP would be assembled with heat exchangers in the collector or hot exhaust injection in the chimney [2, 3]. By this, the new SCPP systems could utilize solar energy as well as the waste heat from industries, especially the low grade waste heat stored in cooling water or hot exhaust gas

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stream, which may improve the efficiency of urban energy systems such as thermal power plants, and hence reduce their carbon emissions.

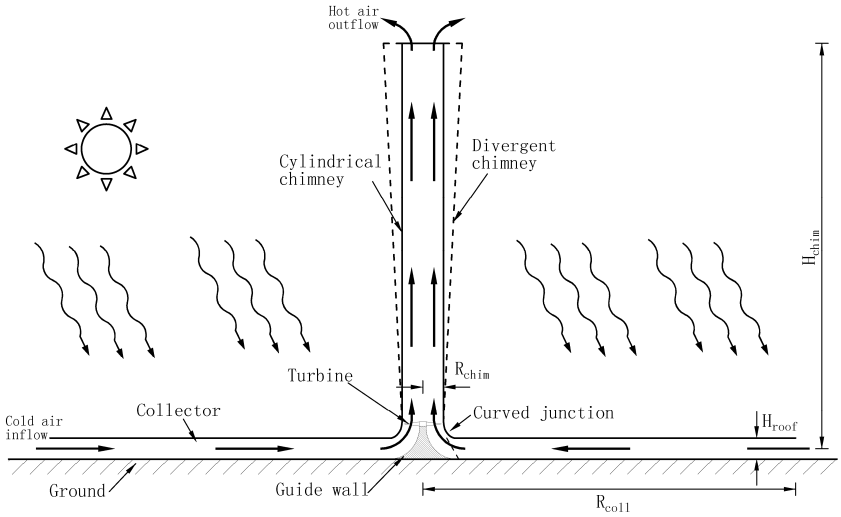


Fig. 1. The guide wall subset (in shadow) locates below the chimney entrance and holds the blades of the turbine.

Studying the impact of the geometry of components in a solar chimney is a primary task. Much attention has been paid to the chimney and the collector [4-7]. The critical roles of design variables, e.g. collector diameter, chimney height, solar radiation and other ambient conditions, to determine the system power output have been widely discussed [4-10]. Guide wall (GW), a component in the collector-to-chimney transition region, is also a prominent subset as it can be used to assist the horizontal air flow in shifting to the updraft and be the holder of the turbine (as shown in Fig. 1). Individual studies revealed the potential impact of the GW on the buoyant flow by examining the systems with and without such a component, which indicated that this subset would be capable of modifying the velocity of the flow and thus significantly affect the performance of SCPP [4, 5]. However, the detailed knowledge on the aerodynamic features of GWs is ambiguous and quantitative evaluation of its impact on the system performance is still uncertain. In other words, it is unknown how the detail geometric parameters, e.g. the height or the radius of GWs, affect the buoyant flow in the system. Therefore, it would be difficult to optimize the geometry of GWs.

In this study, the investigation on GWs was further extended by CFD simulations with GWs with different heights and radiuses. Therefore, variation in the flow in SCPP induced by the modification in the two geometric parameters (i.e. height and radius) were respectively discussed based on the numerical outcomes. By this, we can evaluate the influence from different parameters and identify the critical factors in relation to the aerodynamic features of GWs. Meanwhile, the GWs were coupled to a cylindrical chimney as well as a divergent chimney as some articles found a remarkable improvement of the flow velocity in divergent chimneys [7, 11]. Thus, we have expected different reactions from the divergent-chimney SCPP when the GW configurations varied.