# Modeling of a Biogas Steam Reforming Reactor for Solid Oxide Fuel Cell Systems

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**Introduction**: A biogas steam reforming reactor has been developed in order to be integrated into a proof-of-concept SOFC system, able to operate with biogas produced in an industrial waste water treatment unit. The design of a biogas reactor is the key aspect for the performance and efficiency of a hydrogen generator: weight and volume should be minimized and the heat management system optimized for different operating conditions.

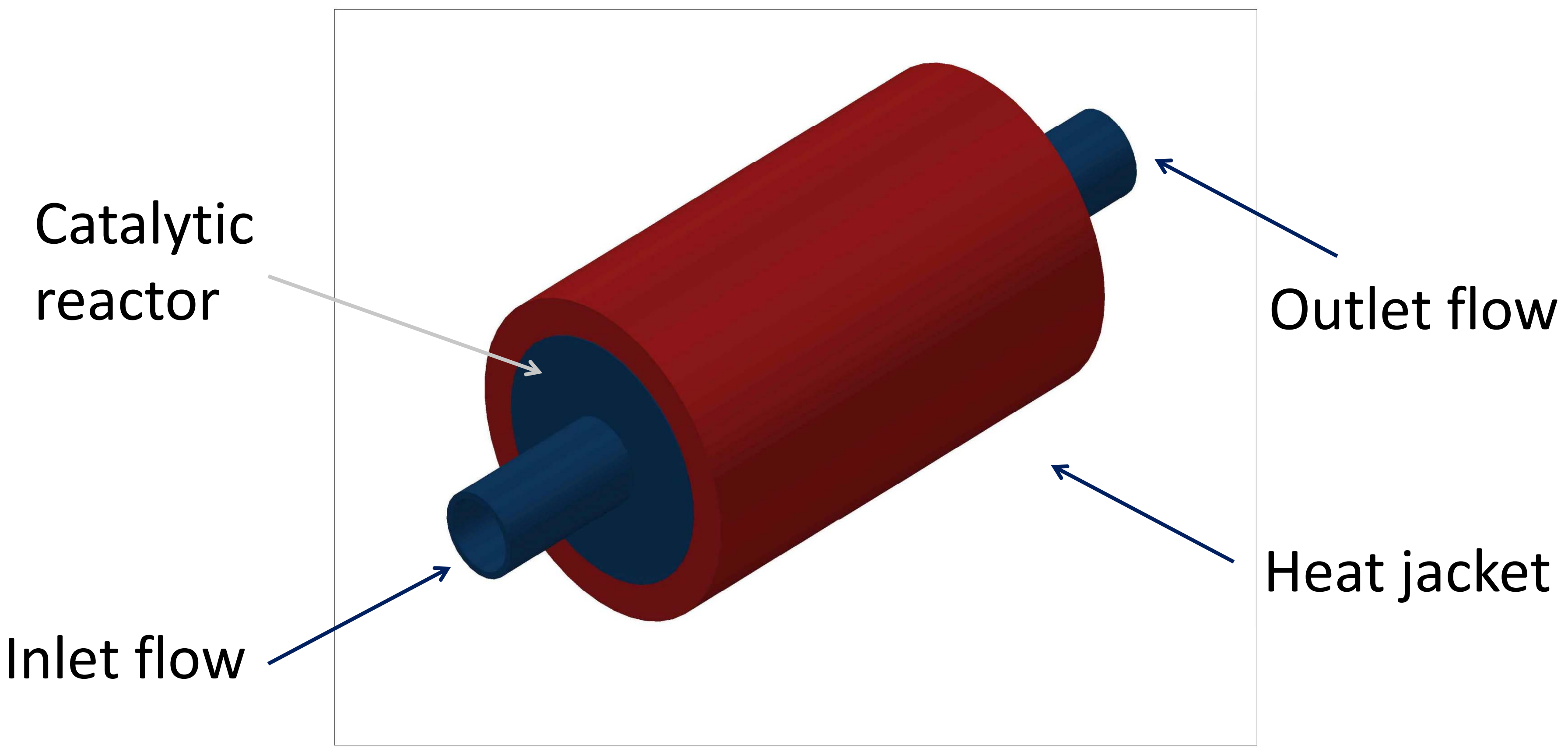

**Figure 1**. Geometry of the steam reforming reactor

**Computational Methods**: According to the literature the following reactions are the prevailing reaction routes [1].

$R_1$: $CH_4+H_2O \leftrightarrow CO+3H_2$
$R_2$: $CH_4+2H_2O \leftrightarrow CO_2+4H_2$
$R_3$: $CO+H_2O \leftrightarrow CO_2+H_2$

A the first two reactions are highly endothermic, excessive amounts of heat have to be supplied to the reactor in order to maintain the desired high temperature.

The reactor is simplified and modeled as a non-isothermal plug flow reactor.

$$\frac{dF_i}{dV}=R_i$$

Species mass balances

$$\sum_i F_i C_{p,i} \frac{dT}{dV}=w_s+Q+Q_{ext}$$

Reactor energy balance

**Results**: The reactor is fed with a total molar flow of 2.4e$^{-2}$ mol·s$^{-1}$. Total methane conversion have been evidenced in the reactor volume for an optimal external heat power supplied.

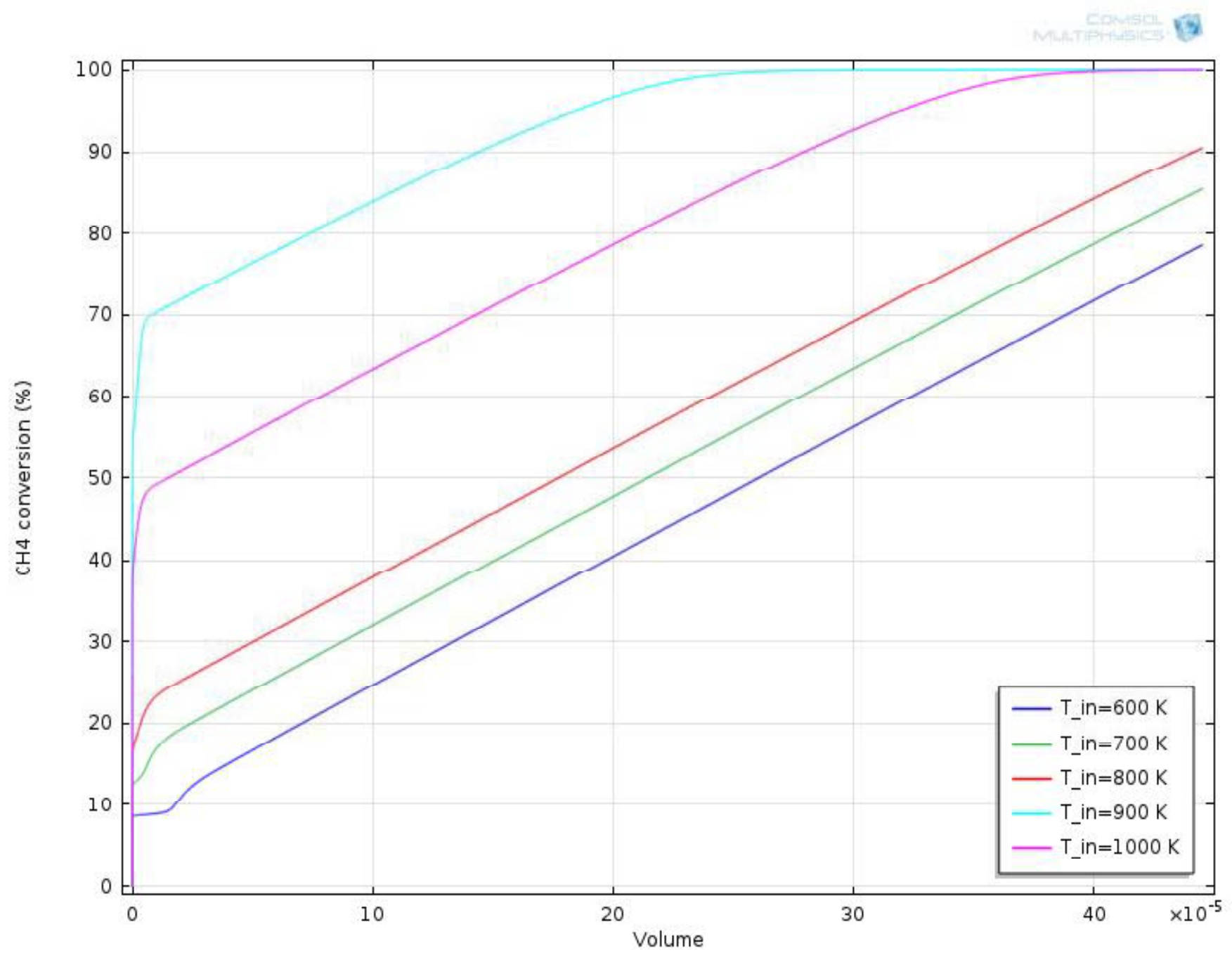

**Figure 2**. Conversion of $CH_4$ (%) as a function of reactor volume (m$^3$), for different inlet temperature

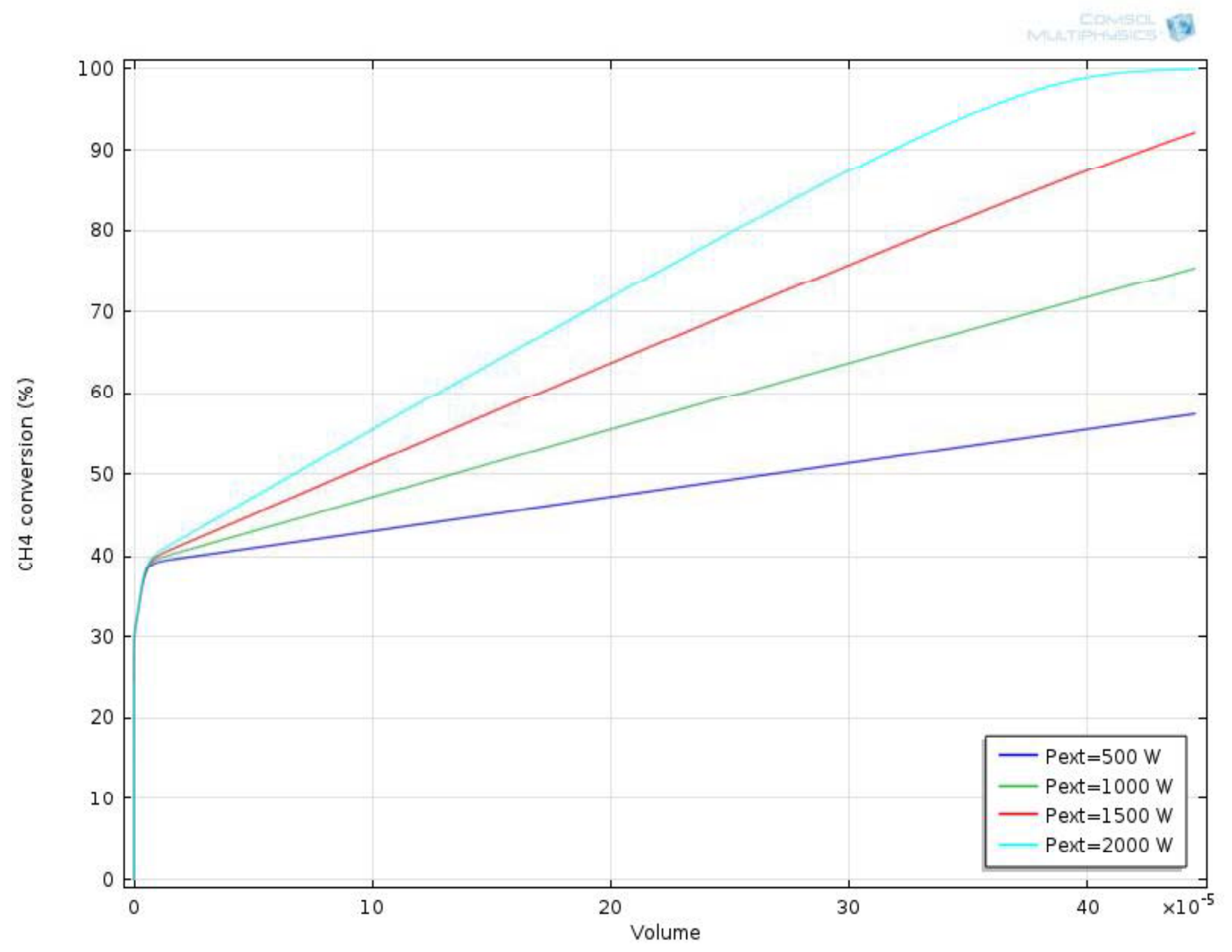

**Figure 3**. Conversion of $CH_4$ (%) as a function of reactor volume (m$^3$), for different external heat power supplied

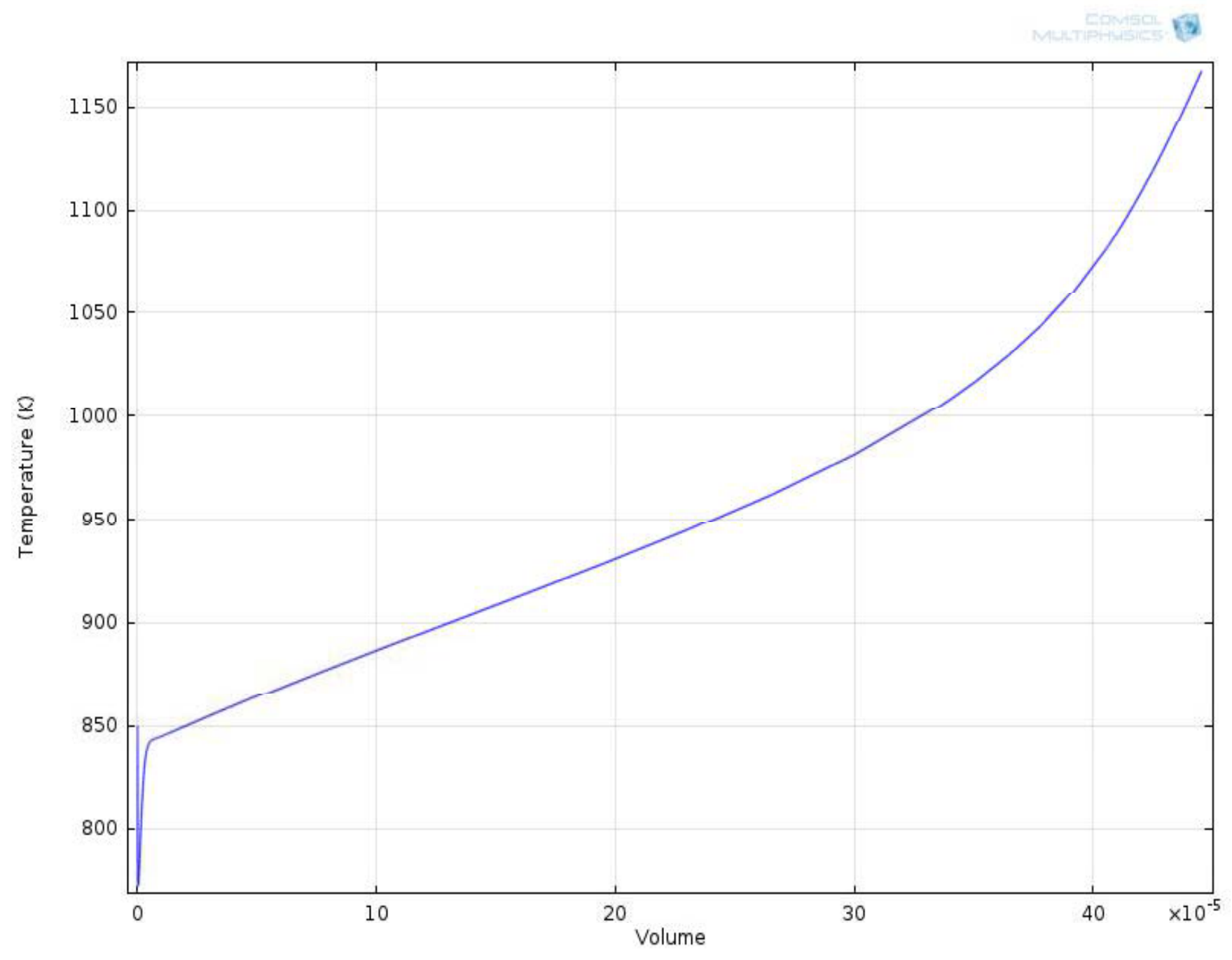

**Figure 4**. Temperature (K) as a function of volume (m$^3$) for a reactor equipped with an optimal heat exchanger jacket

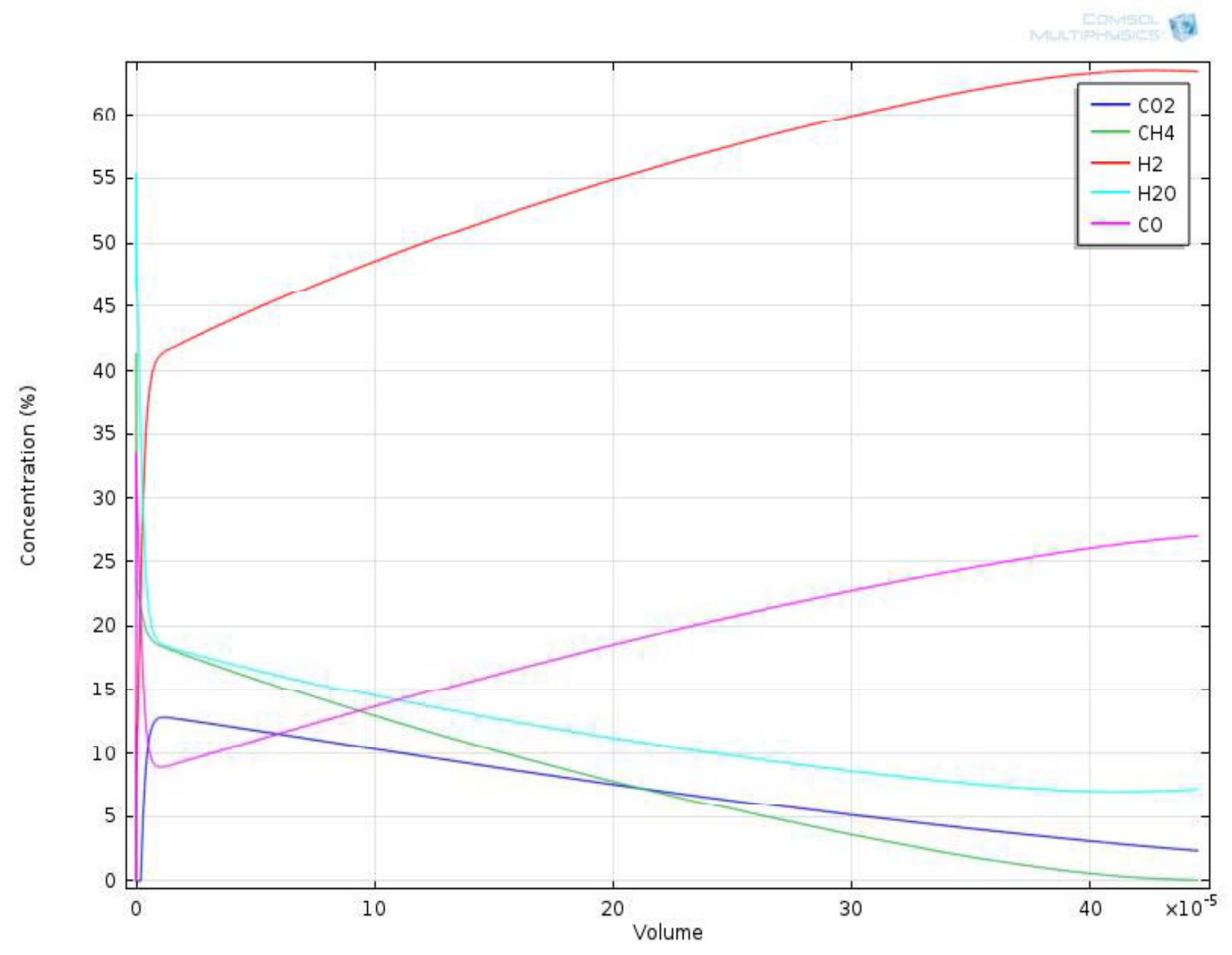

**Figure 5**. Product concentration (%) as a function of reactor volume (m$^3$) with an optimal heat exchanger jacket

**Conclusions**: Simulation studies aimed at investigating the biogas steam reforming reaction have been successfully performed. A 2D model of the reactor will be set up, including mass transport, heat transfer, and fluid flow in order to provide insight information for optimizing operation parameters, comparing with experimental data.

**References**:

1. D.G. Avraam, T.I. Halkides, D.K. Liguras, O.a. Bereketidou, M.A. Goula, An experimental and theoretical approach for the biogas steam reforming reaction, Int. J. of Hydrogen Energy, 35, 9818-9827 (2010)

Excerpt from the Proceedings of the 2013 COMSOL Conference in Rotterdam