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# Comparison of two different (quasi-) dynamic testing methods for the performance evaluation of a Linear Fresnel Process Heat Collector

A. Hofer[a]*, D. Büchner[a], K. Kramer[a], S. Fahr[a], A. Heimsath[a], W.J. Platzer[a], S. Scholl[b]

[a]*Scientific Researcher, Fraunhofer Institute for Solar Energy Systems ISE, Heidenhofstr. 2, 79110 Freiburg, Germany.*
[b]*Prof. Dr.-Ing., Head of Institute for Chemical and Thermal Process Engineering ICTV, Technical University Braunschweig, Langer Kamp 7, 38106 Braunschweig, Germany.*

**Abstract**

A small-scale Linear Fresnel Collector (LFC) for the generation of process heat has been tested by Fraunhofer ISE; its performance was evaluated by means of two different methods. The first is a quasi-dynamic testing method performed according to the testing standard ISO 9806:2013, with modifications in the model to accurately describe LFCs. Due to the two-dimensional Incidence Angle Modifier (IAM) of an LFC, an iterative multi-linear regression (MLR) approach has been developed to be able to comprehensively evaluate the optical performance. The second method is a dynamic testing method based on a parameter identification incorporating a multi-node/plug-flow collector model without strict restraints on mass flow and inlet temperature stability.

Both methods are briefly described in their conceptual design and their basic requirements, revealing their similarities and differences. Each method is then applied to real measurement data from an LFC, assessing practicability and identification accuracy. For both methods, the mean absolute difference between identified IAM values and results from ray tracing fell in a range of 0.013-0.017, leading to a similar accuracy in LFC performance evaluation. Differences in optical efficiency between the two methods are smaller, with an average absolute difference below 0.0098, even when using different measurement data and simulation models. Thus the dynamic method represents a good starting point for the further development of an alternative dynamic testing and evaluation method with more flexibility than the current testing standard. This will be significant when evaluating large-scale concentrating collectors and collectors with direct steam generation.


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* Corresponding author. Tel.: +49-761-4588-5991; Fax: +49-761-4588-9410.
*E-mail address:* Annie.Hofer@ise.fraunhofer.de


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**Nomenclature**

| | |
|---|---|
| $A_{ap}$ | aperture area [m²] |
| $c_1/c_2$ | heat loss coefficients of QDT-method per aperture area [W/(m²K)] [W/(m² K²)] |
| $c_5$ | capacity coefficient of QDT-method [W/m²] |
| $c_p$ | thermal capacity [kJ/(kgK)] |
| $\eta_{opt}$ | optical efficiency respectively conversion factor |
| $\eta_{opt,0}$ | optical efficiency respectively conversion factor at normal incidence |
| $f_{end}$ | end loss factor |
| $\gamma_s$ | azimuth angle |
| $G_b$ | beam irradiation [W/m²] |
| $G_d$ | diffuse irradiation [W/m²] |
| $IAM_{t/l}$ | transversal/longitudinal incidence angle modifier |
| $K_d$ | diffuse incidence angle modifier for diffuse irradiation |
| $\dot{m}_{meas}$ | mass flow [kg/s] |
| $n$ | number of nodes |
| $\dot{Q}_{abs}$ | solar radiation incident on absorber [W/m] |
| $\dot{Q}_{loss}$ | heat loss of absorber |
| $\dot{Q}_{out\_col}$ | thermal power output of collector [W] |
| $T_{amb}$ | ambient temperature [°C] |
| $\theta_i$ | incidence angle |
| $\theta_t$ | transversal angle |
| $\theta_z$ | zenith angle |
| $T_{HTF\_n}$ | heat transfer fluid temperature in node n [°C] |
| $T_{in}/T_{out}$ | inlet/outlet fluid temperature of collector [°C] |
| $T_m$ | mean fluid temperature of collector $(T_{in} + T_{out})/2$ [°C] |
| $u_0/u_1$ | heat loss coefficients of DT-method per receiver length [W/(mK)] [W/(mK²)] |

**Abbreviations**

| | |
|---|---|
| PVT | Photovoltaic-Thermal |
| LFC | Linear Fresnel Collector |
| PTC | Parabolic Trough Collector |
| ETC | Evacuated Tubular Collectors |
| FPC | Flat Plate Collectors |
| DNI | Direct Normal Irradiance |
| QDT | Quasi-Dynamic Testing |
| DT | Dynamic Testing |
| MLR | Multiple Linear Regression |

## 1. Introduction

With the recent publication of the testing standard ISO 9806:2013 [1], the European testing standard EN 12975-2 [2] and the former ISO 9806-1,2,3 [3-5] are being replaced, merged and technically revised. The testing methods contained therein are applicable not only to flat plate collectors (FPC) and Evacuated Tubular Collectors (ETC) but also to other special kinds of solar collectors like Air Heating Collectors, PVT collectors and (tracking)