Current and Future Development of greenius

Recent Updates and Outlook on Next Release

Simon Dieckmann

greenius User Day 2015

Cologne, 30 Sep 2015

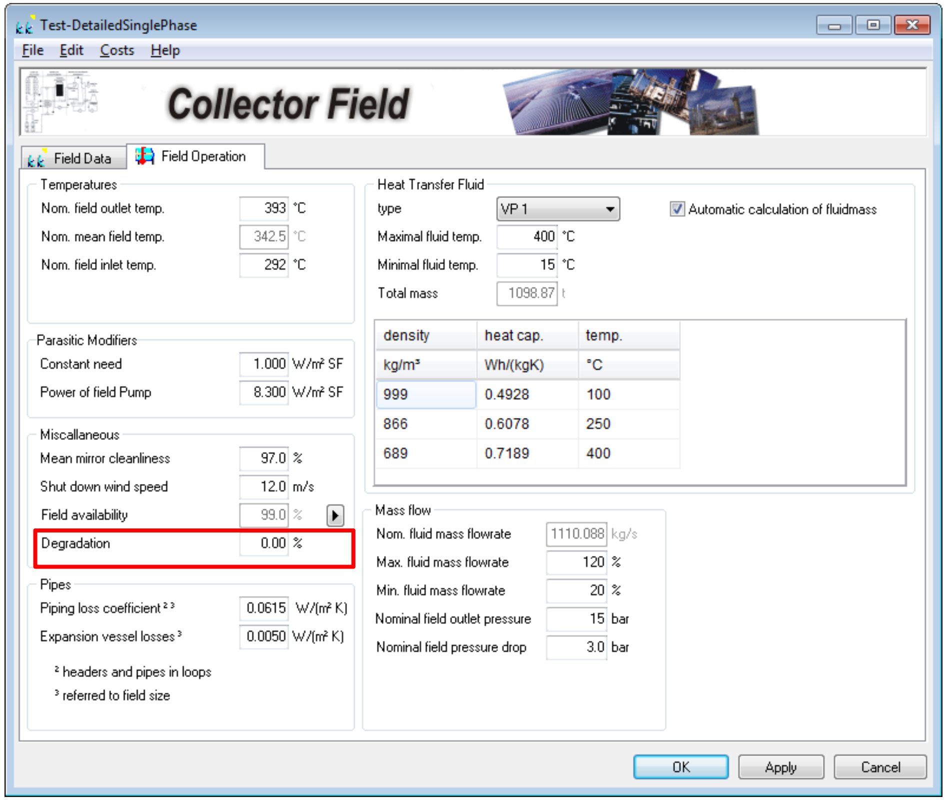
Content

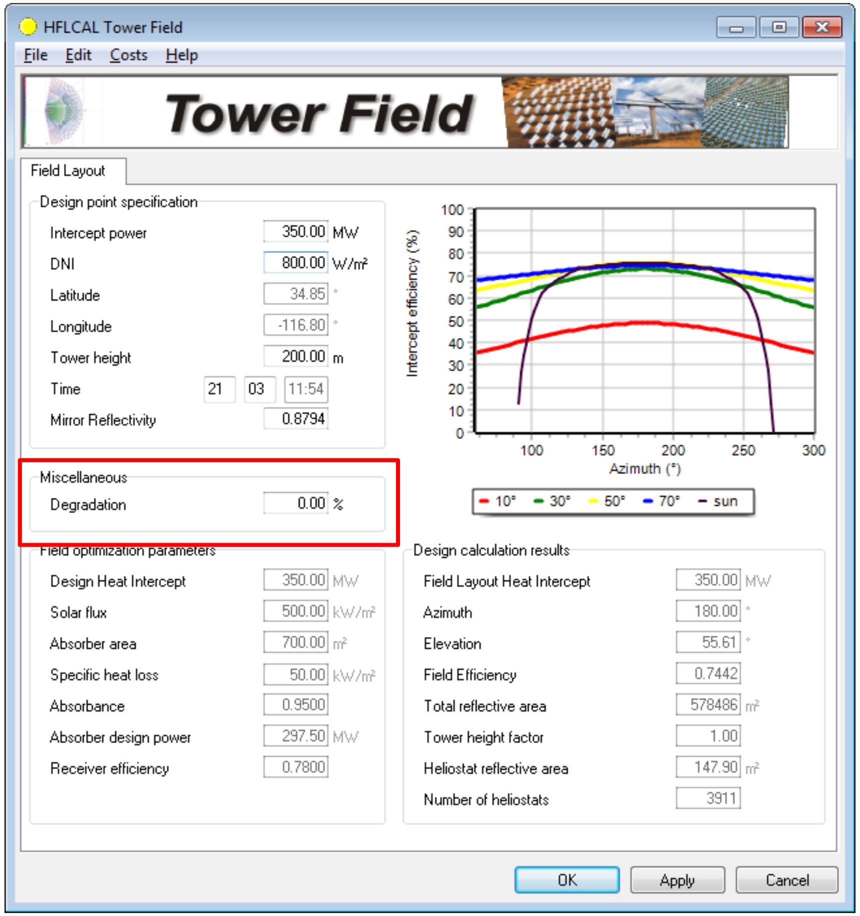
1. **Released Updates since October 2014**
2. Updates in the new release (October 2015)
3. Future Development

Released Updates with Version 4.0.8.1

- Additional 21 new wind turbines are now shipped with **greenius**. Some old turbines were removed.
- Bug Fixing for all technologies for step lengths < 1h
- Degradation is included
- Release notes come now with **greenius**
- Manual now comes shipped with **greenius**
- Several minor bugs fixed

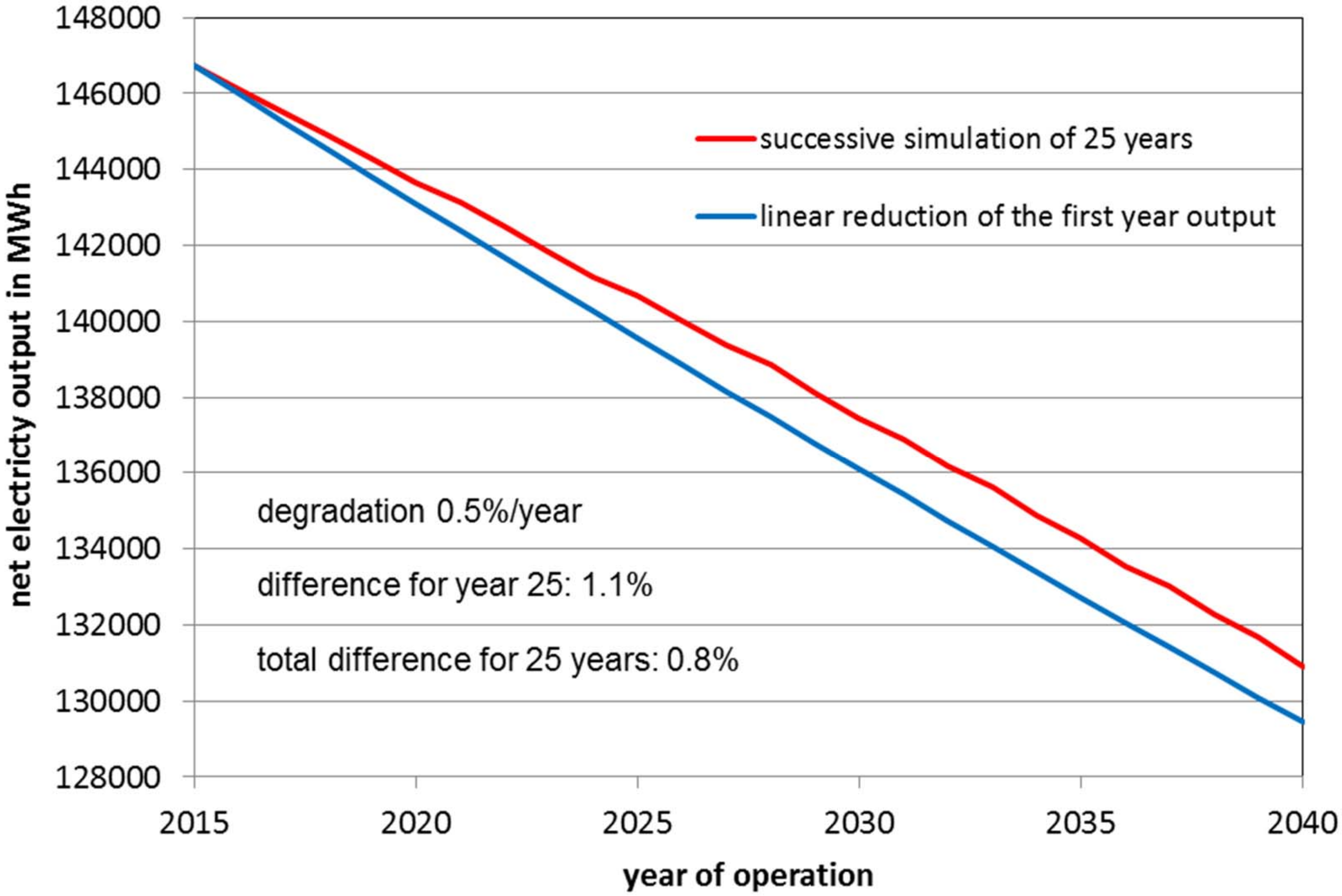
Accounting for Degradation in greenius





DLR

Comparison of Flat-Rate and Detailed Approach



Content

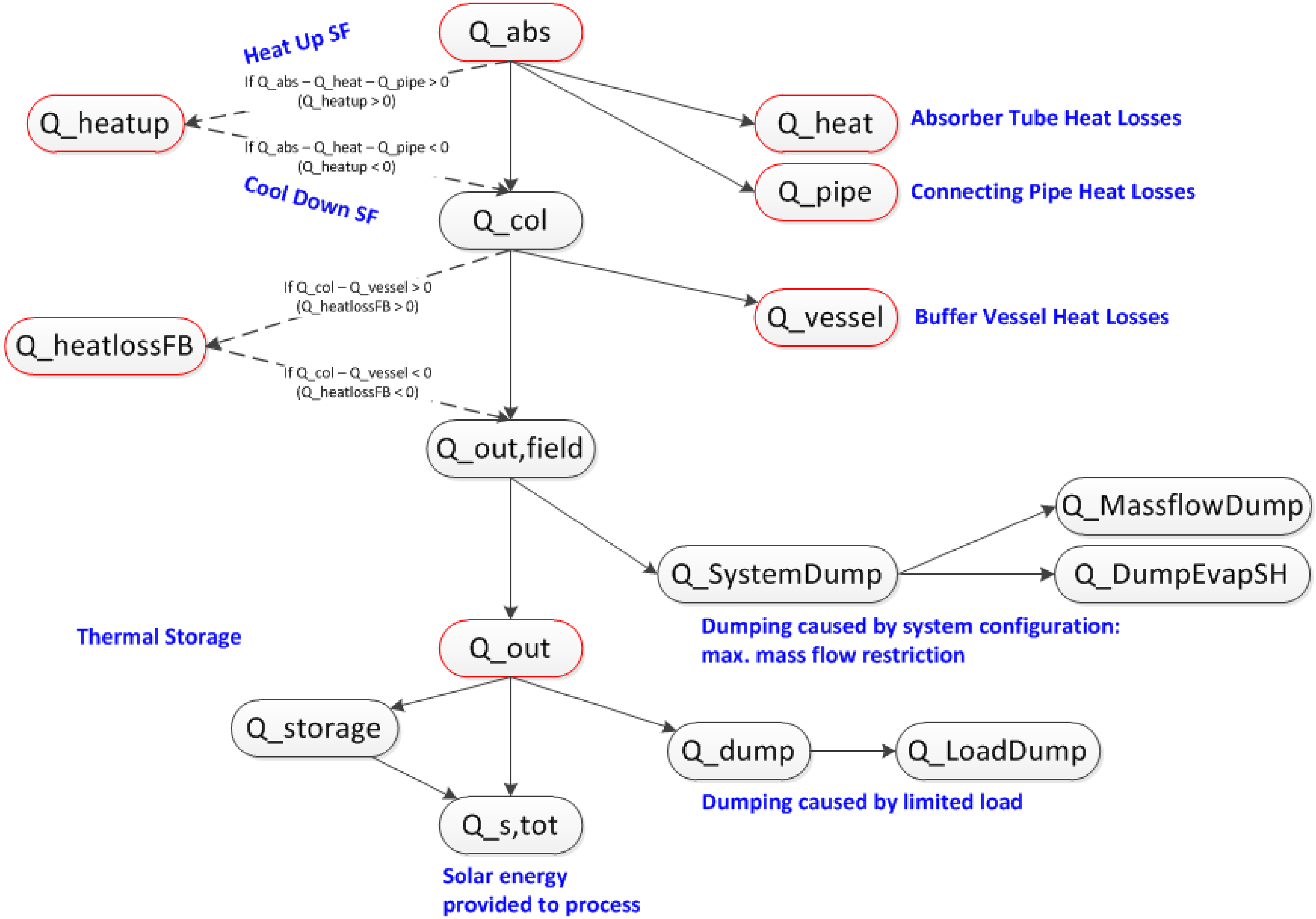
Overview of Changes for the next release

- Freeze Protection → *see Molten Salt presentation by Jürgen Dersch*
- Implementation of CoolProp steam table
- Modification and documentation of output variables for line focusing systems
- Enhanced model for DSG
  - Optimisation of calculation algorithm
    → Reduce computational time
  - Modification of physics
  - Intensive validation

Overview of Steam Tables for greenius

- Greenius includes interfaces for the following steam table libraries
  - Extended IAPWS-IF97 Steam Tables (Book with CD / eBook)
    http://www.springer.com/3-540-21419-4
  - WinSteam (Trial Version available)
    http://www.techwareeng.com/prodws.html
  - CoolProp (extremely slow, not recommended)
    http://www.coolprop.org/
  - FreeSteam (To be implemented)
    http://freesteam.sourceforge.net/
- More detailed information on usage of the libraries will be added to Help & Manual in the next release

Proposed Scheme of Output Variables



Enhanced Model – Optimisation / Speed Up

- Several measures in order to improve solver convergence
  - Simplified Newton‘s method
  - Manual Calculation of the Jacobi matrix
  - Scaling
- Total reduction of simulation time: 87%

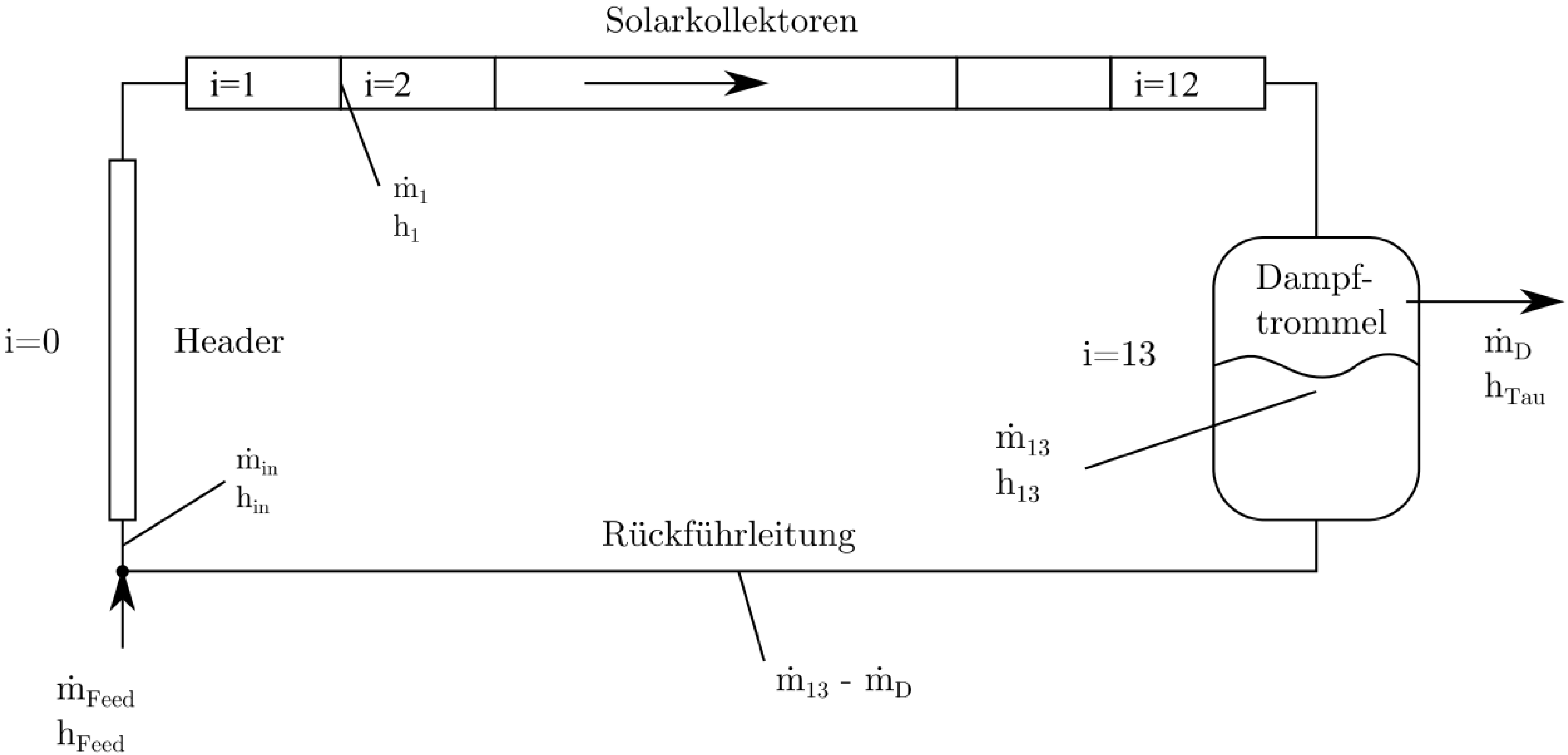
Maßnahme	**Zeitersparnis**		**Iterationen**	**Updates JM**
	Einzeln	**Kumulativ**		
Ausgangszustand	0.0 %	0.0 %	37 835	29 887
Vereinfachtes Newton-Verfahren	48.1 %	48.1 %	93 642	11 891
Manuelle, redundanzfreie Berechnung der JM	58.1 %	78.2 %	93 483	13 276
Vorgabe bekannter Nullen	2.0 %	78.7 %	93 483	13 276
Optimierung JM-Aktualisierung	22.2 %	83.4 %	47 020	21 824
Skalierung	23.4 %	87.3 %	32 447	15 621

DLR

Enhanced Model – Previous Issues

- Assumption of a constant mass flow is unrealistic, especially close to boiling point
- Unrealistic enthalpy profiles over loop length
  → especially for fine temporal resolutions
- Significant deviations from dynamic models
- Initial guess based on realistic conditions is not appropriate for a model which leads to unrealistic enthalpy profiles
  → Worse convergence
- Sometimes extreme fluctuation of the solution
  → Worse convergence

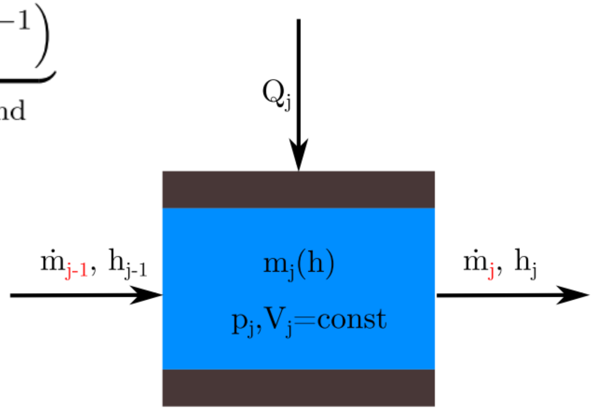
Enhanced Model – Modification of Physics I



Enhanced Model – Modification of Physics II
Enthalpy Balance

Classic Model:

$$Q_j^k = \underbrace{\dot{m}^k \left(h_j^k - h_{j-1}^k\right) \Delta t}_{\text{Konvektiver Transport}} + \underbrace{m_j^k h_j^k - m_j^{k-1} h_j^{k-1}}_{\text{Aufheizung Massendifferenz}} + \underbrace{m_w c_{p,w} \left(T_j^k - T_j^{k-1}\right)}_{\text{Aufheizung Rohrwand}}$$

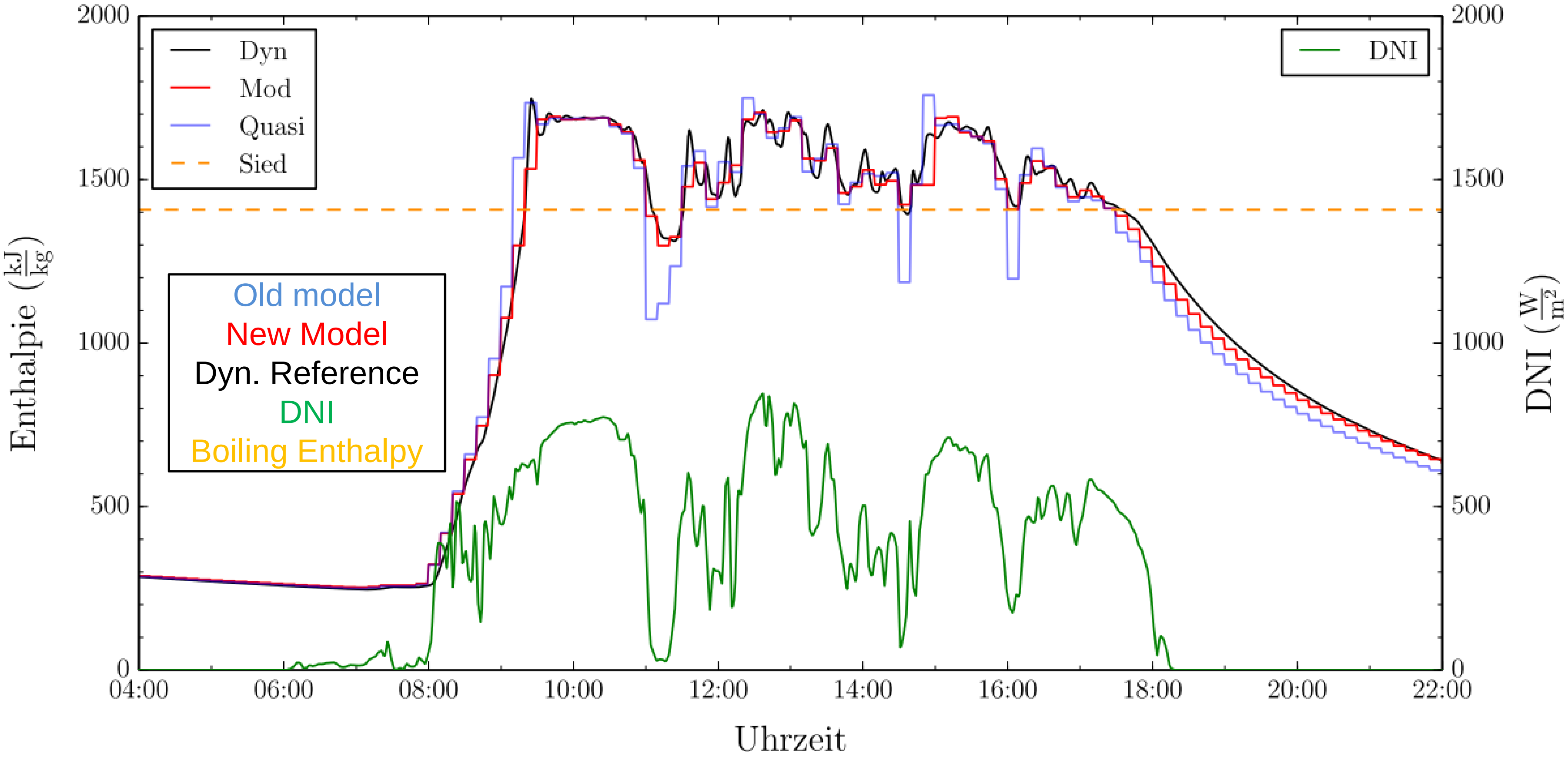


→ *Allow variation of mass flow*

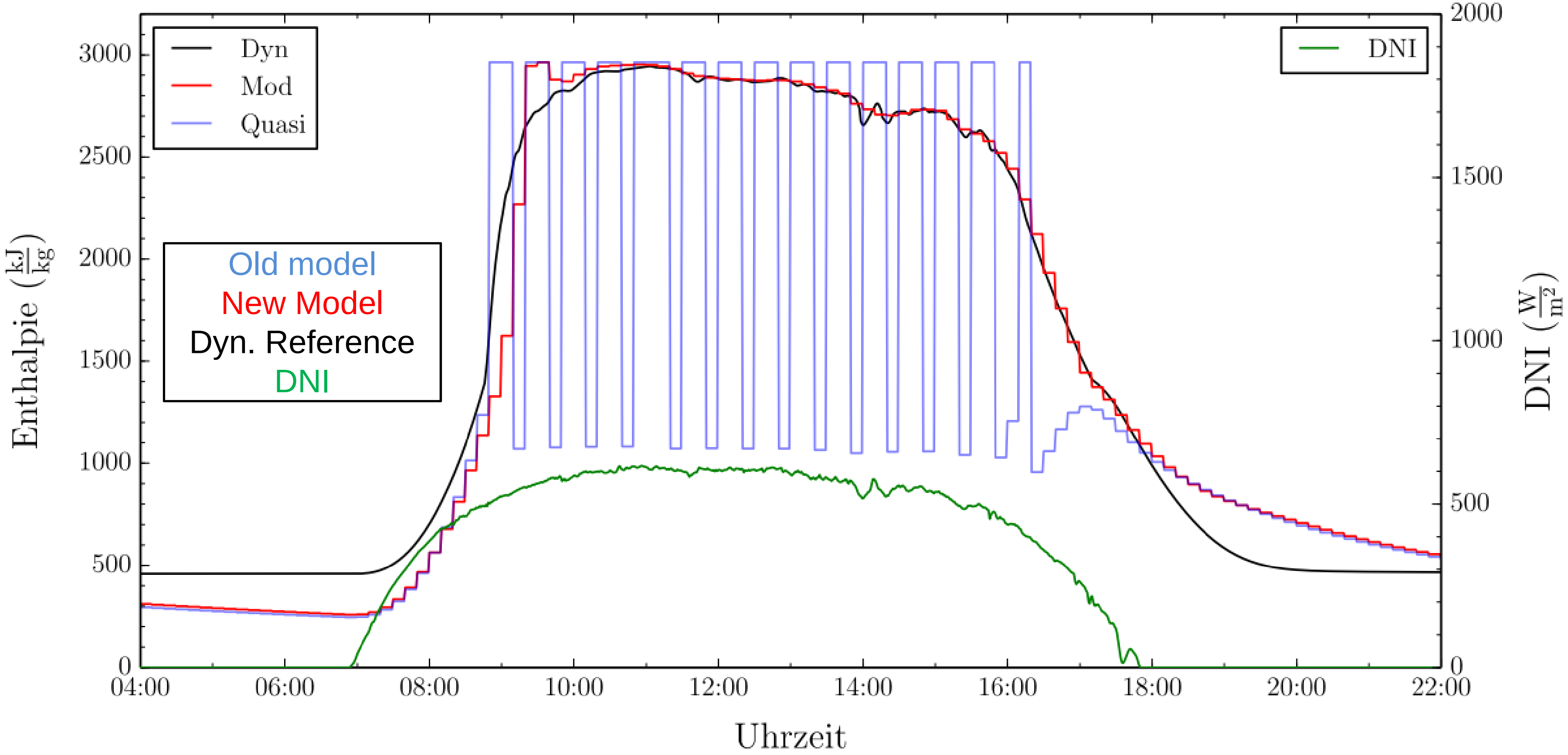
New Model:

$$Q_j^k = \underbrace{\left(\dot{m}_j^k h_j^k - \dot{m}_{j-1}^k h_{j-1}^k\right) \Delta t}_{\text{Konvektiver Transport}} + \underbrace{m_j^k h_j^k - m_j^{k-1} h_j^{k-1}}_{\text{Aufheizung Massendifferenz}} + \underbrace{m_w c_{p,w} \left(T_j^k - T_j^{k-1}\right)}_{\text{Aufheizung Rohrwand}}$$

Enhanced Model – Modification of Physics III
Enthalpy at Field Outlet (Recirculation)



Enhanced Model – Modification of Physics IV
Enthalpy at field outlet (1-Through)



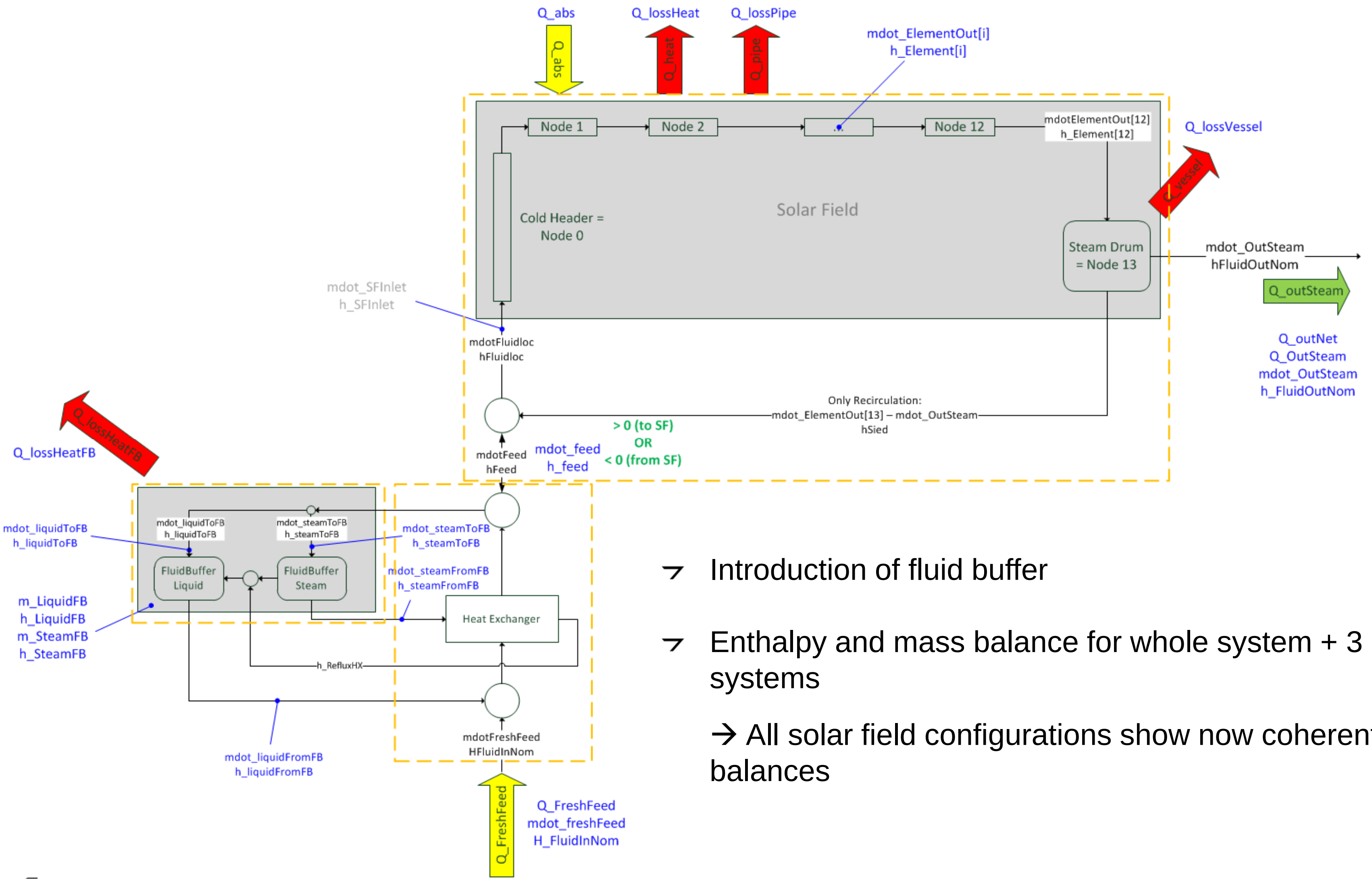
Enhanced Model – Modification of Physics V Summary

Annual solar field output:

DNI	Quasi	Mod
Kanchanaburi	-1.39 %	-3.08 %
Almeria	+0.60 %	-0.54 %
Granada	+0.37 %	-0.61 %

- Advantages of new model
  - Enthalpy and mass flow profiles are modeled correctly
  - No implausible enthalpy profiles over loop length
  - More robust
  - 10-15% faster
- Disadvantages of new model
  - Implementation is much more complex
    → Mass flow difference between SF inlet and outlet

Enhanced Model – Fluid Buffer and Validation



- Introduction of fluid buffer
- Enthalpy and mass balance for whole system + 3 sub systems

  → All solar field configurations show now coherent balances

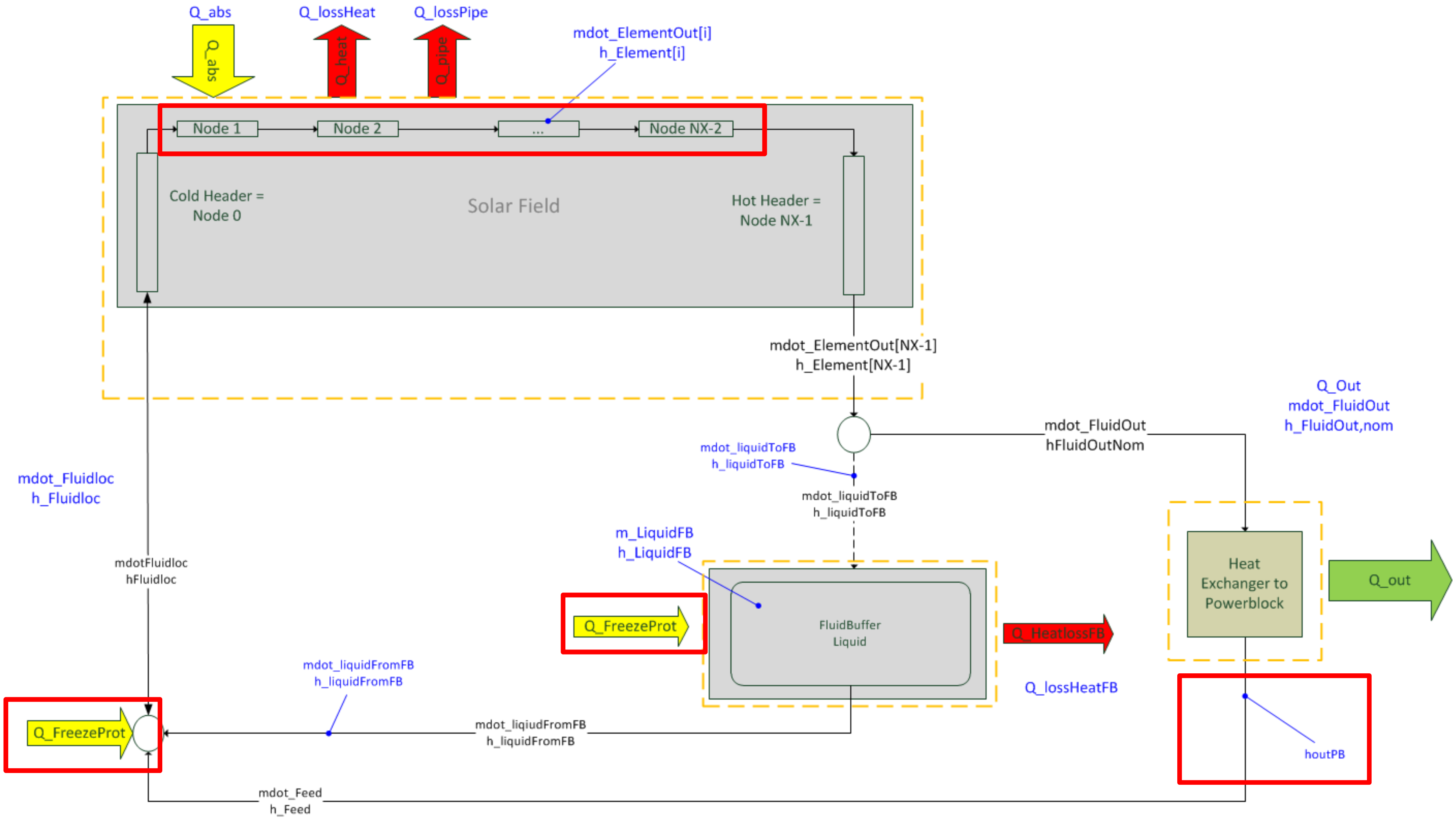
Content

1. Released Updates since October 2014
2. Updates in the new release (October 2015)
3. **Future Development**

Concrete Future Development Plans

- Interface for FreeSteam Library for DSG
- Enhanced model for single phase HTFs in line focusing solar systems
  - Spatial resolution single phase fluids
  - Freeze protection
  - Variable HTF return temperature at partial power block load
- Salt and water/steam as HTFs in solar towers

Example: Scheme of New Model for Single Phase Fluids



THANK YOU
for your attention.

Supported by:

Federal Ministry
for Economic Affairs
and Energy

on the basis of a decision
by the German Bundestag

FreeGreenius: Contract no. 0325427

DLR