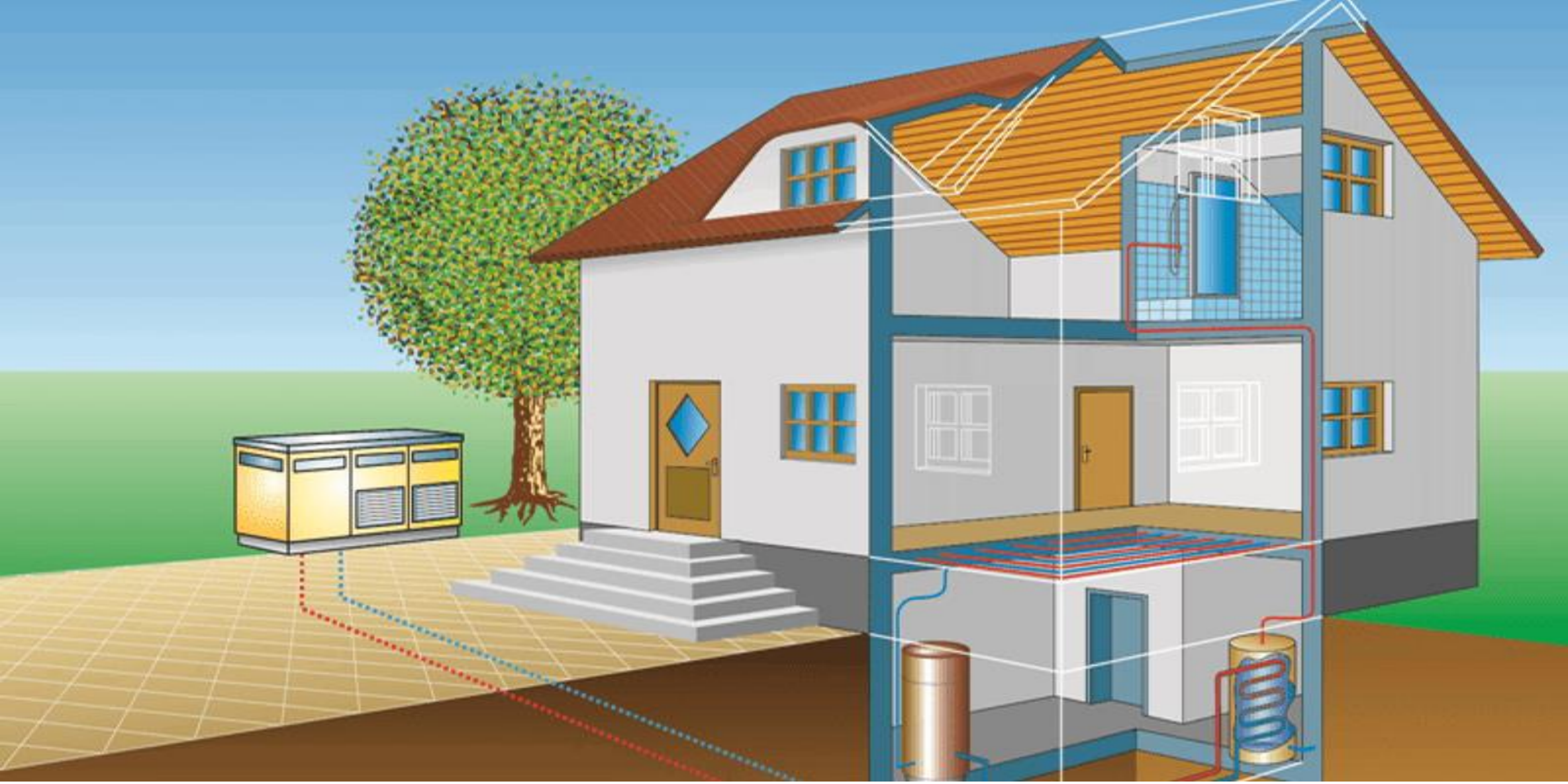


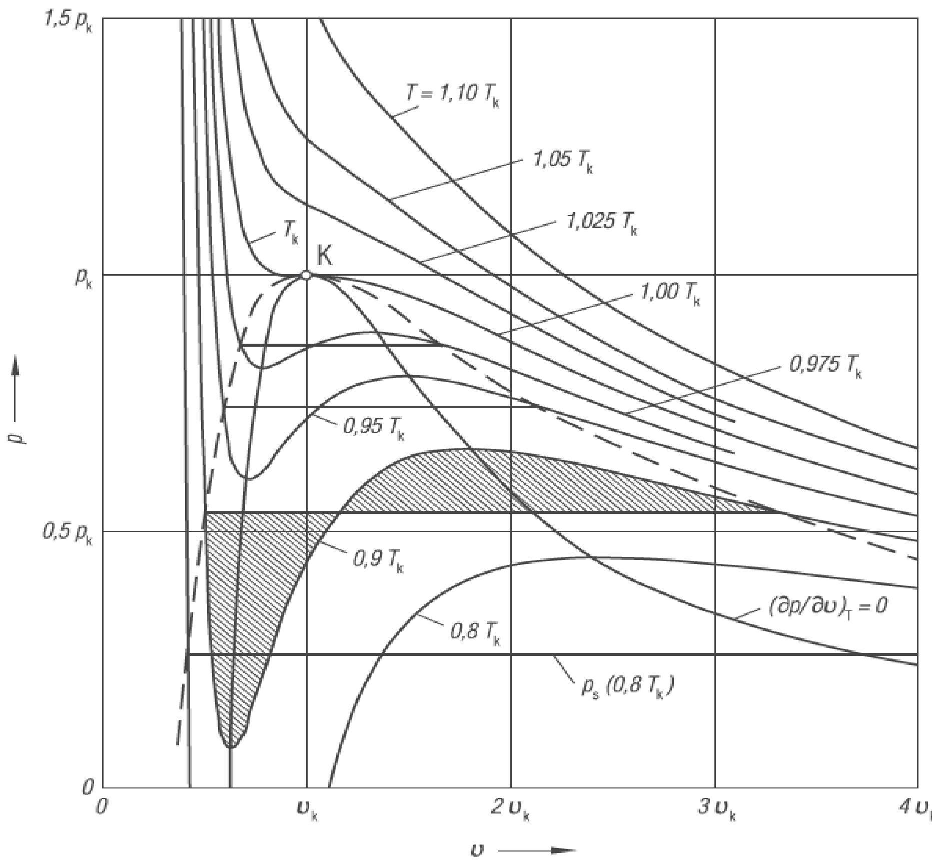
Refrigerant Models

Refrigerant Model Development

- **First Models**
  - Hybrid procedure
  - Equation of State

$$\alpha(\delta,\tau) = \alpha^0(\delta,\tau) + \alpha^r(\delta,\tau) = \frac{a(\delta,\tau)}{RT}$$

  - Regression functions
    - $y = f(x) + \epsilon$
    - Maxwell-criterion (two-phase area)



[1]

- **Further steps**
  - Compliance with measurement uncertainty
  - Overcriticial view (CO_2)

- **Next Steps**
  - Comparision of speed and accuracy (two-phase area)
  - Development of a mixture refrigerant model

Two-phase area

- Fitting of a regression function
  - $p_{sat}, \varrho_{liquid}, \varrho_{vapor} \Rightarrow f(T_{sat})$
  - $T_{sat}, h_{liquid}, h_{vapor}, s_{liquid}, s_{vapor} \Rightarrow f(p_{sat})$
- Quality criteria
  - Maximum relative error
  - NRMSE

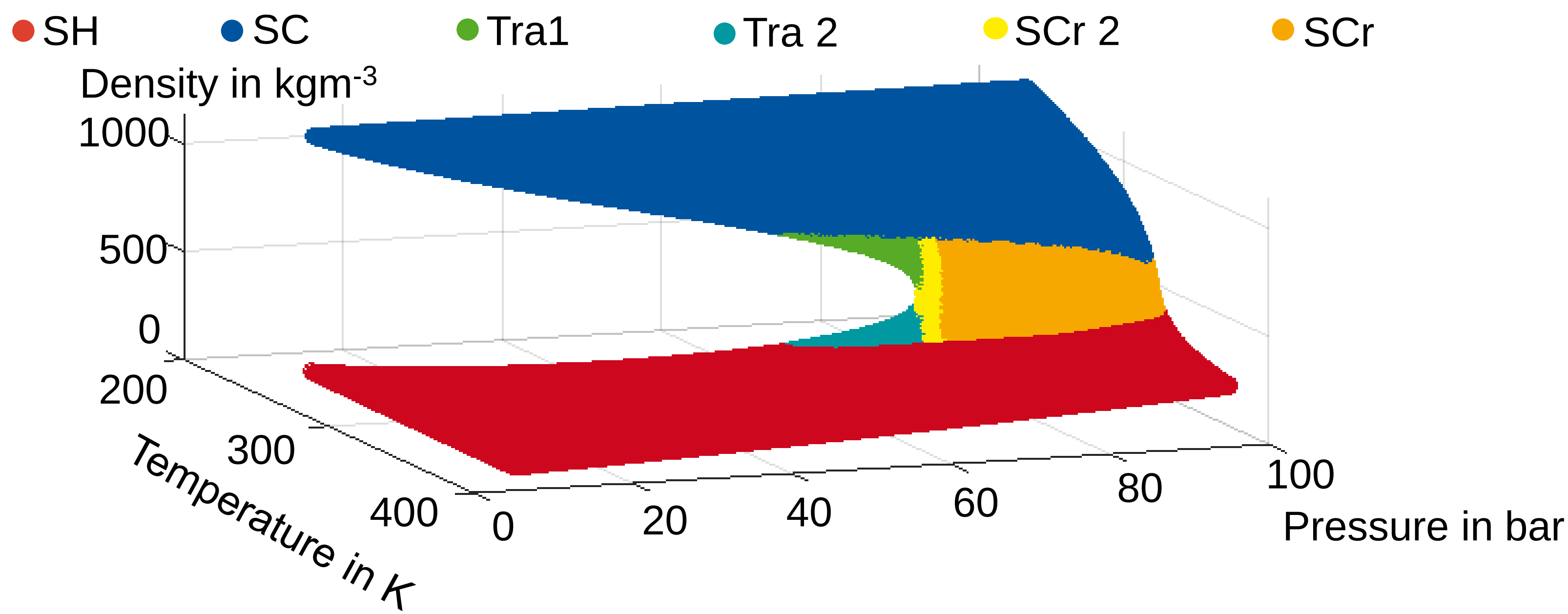
	Functiontype	Numbers	MaxRelErr	NRMSE
p_{sat}	Exp	4 pcs.	0.16 %	4.62E-4
T_{sat}	Poly	20 pcs.	0.006 %	1.66E-5
ϱ_{liquid}	Exp	20 pcs.	0.005 %	6.46E-6
ϱ_{vapor}	Exp	12 pcs.	0.011 %	4.68E-6
h_{liquid}	Poly	20 pcs.	0.26 %	1.9E-4
h_{vapor}	Exp	10 pcs.	0.24 %	2.8E-3
s_{liquid}	Poly	18 pcs.	0.16 %	3.5E-4
s_{vapor}	Exp	10 pcs.	0.11 %	5.5E-4

Single-phase area

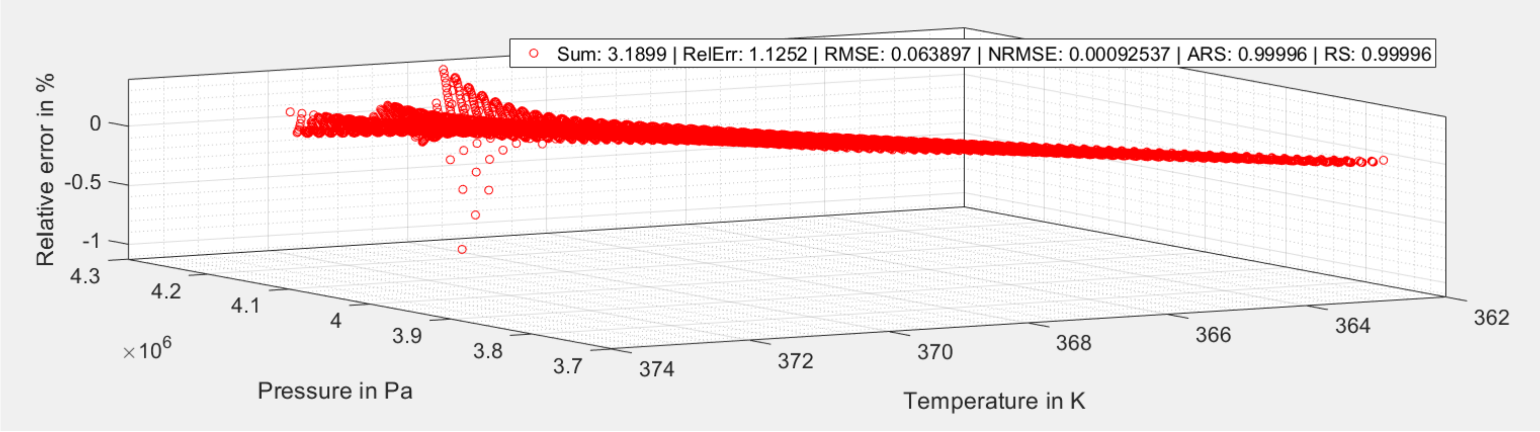
- Separated consideration of
  - $\varrho_{liquid,vapor,criticial} \Rightarrow f(p,T)$
  - $T_{liquid,vapor,criticial} \Rightarrow f(p,h)$
  - $T_{liquid,vapor,criticial} \Rightarrow f(p,s)$

- Divide into different Regions
  - Subcooled (SC)
  - Superheated (SH)
  - Critical (SCr)
  - Second critical area (SCr2) → density
  - Transition areas (Tra1+Tra2) → density

Results of the single-phase area – Density



Example Tra2:



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Divergences