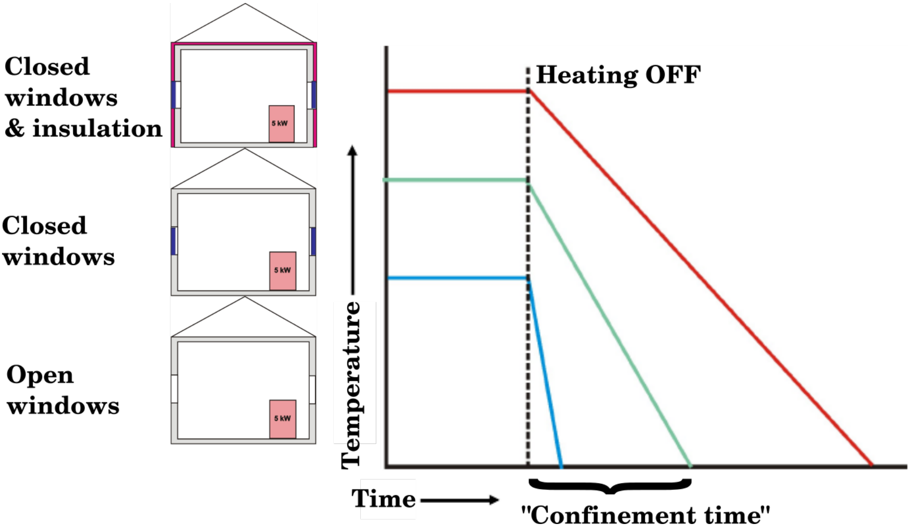
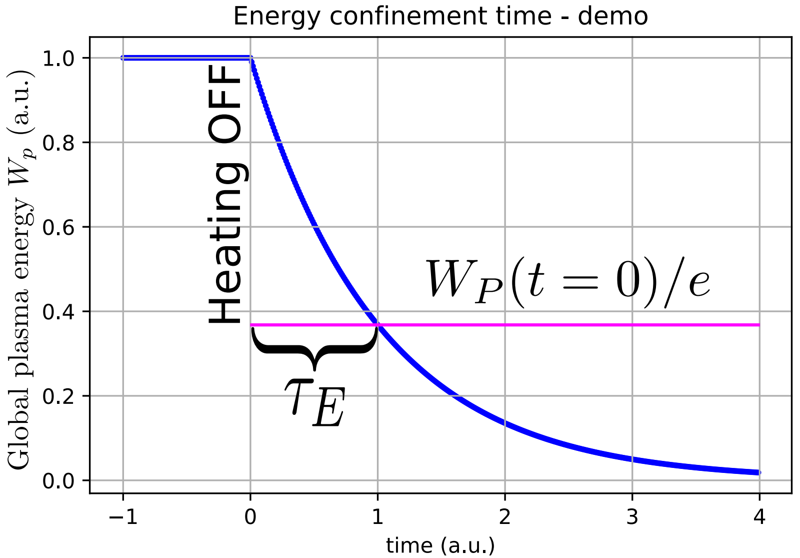
Energy balance of the house



Energy balance of the tokamak



Energy confinement time

Under the assumption of a simplified power balance, the heating power P_H is partially absorbed in the plasma and leads to an increase of the plasma energy W_p and the rest is lost as the loss power P_L

$$P_H = \frac{dW_p}{dt} + P_L$$

The energy confinement time is defined as the characteristic time scale of the exponential decay of the plasma energy W_p due to the loss power P_L:

$$\tau_E = \frac{W_p}{P_L} = \frac{W_p}{P_H - dW_p/dt}$$

Choosing the quasistationary phase of the plasma discharge, where $\frac{dW_p}{dt} = 0$ gives:

$$\tau_E(t) = \frac{W_p(t)}{P_H(t)}$$

Plasma heating power

On the GOLEM tokamak the only heating mechanism of the plasma is ohmic heating P_{OH} resulting from the plasma current I_p flowing in a conductor with finite resistivity R_p. The time dependence of the ohmic heating power can be calculated as:

$$P_H(t) = P_{OH}(t) = R_p(t) \cdot I_p^2(t)$$

Plasma Energy

The global plasma energy content W_p can be simply calculated from the temperature estimation $T_e(0,t)$, average density n_e and plasma volume V_p, based on the ideal gas law, taking into account the assumed $T_e(r,t) = T_e(0,t)\left(1-\frac{r^2}{a^2}\right)^2$ temperature profile:

$$W_p(t) = V_p \frac{n_e k_B T_e(0,t)}{3}.$$

The information that the magnetic field reduces the degrees of freedom of the particles to two has been used to derive this formula.

- $V_p \approx 80$ l

Central Electron Temperature estimation (Spitzer Formula)

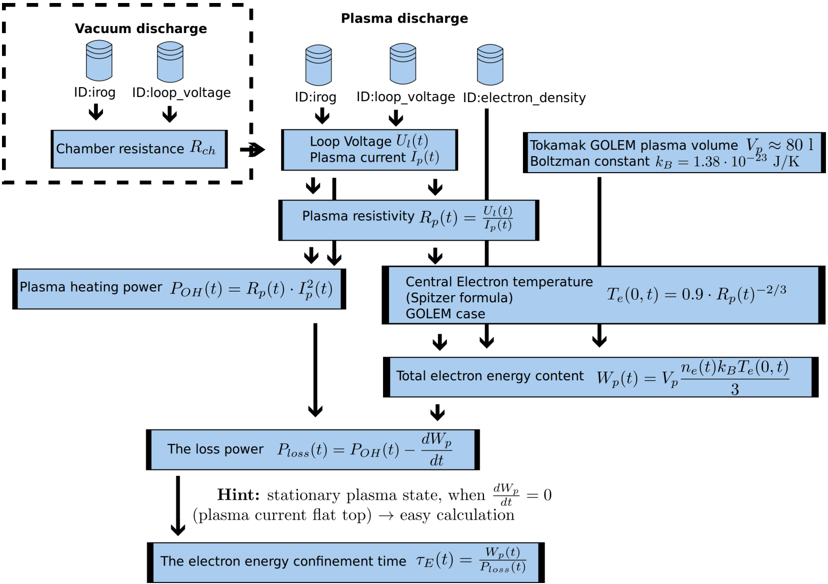
The time evolution of the central electron temperature $T_e(0,t)$ is calculated from equation based on Spitzer's resistivity formula (see eg. [Brotankova, J., 2009],[Wesson, 2004]):

$$T_e(0,t) = \left(\frac{R_0}{a^2} \frac{8 Z_{eff.}}{1544} \frac{1}{R_p(t)} \right)^{2/3}, [eV; m, \Omega]$$

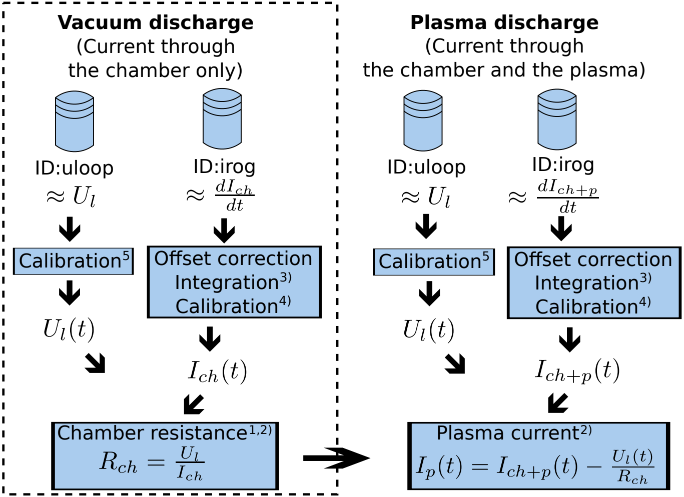
For particular case of the GOLEM tokamak it says:

$$T_e(0,t) = 0.9 \cdot \left(\frac{I_p(t)}{U_l(t)} \right)^{2/3}, [eV; A, V]$$

Towards Electron energy confinement time τ_E



Towards Plasma current I_p



1) With some statistical effort. 2) Do it in the stationary phase, i.e. current constant, to avoid inductive phenomena. 3) 1 us step. 4) Rogowski Coil calibration constant = 5.3 . 10^6 A/Vs 5) Uloop calibration constant = 5.5

Brotankova, J. (PhD. thesis 2009).
Study of high temperature plasma in tokamak-like experimental devices.

Wesson, J. (Third Edition, 2004).
Tokamaks, volume 118 of *International Series of Monographs on Physics*.
Oxford University Press Inc., New York.