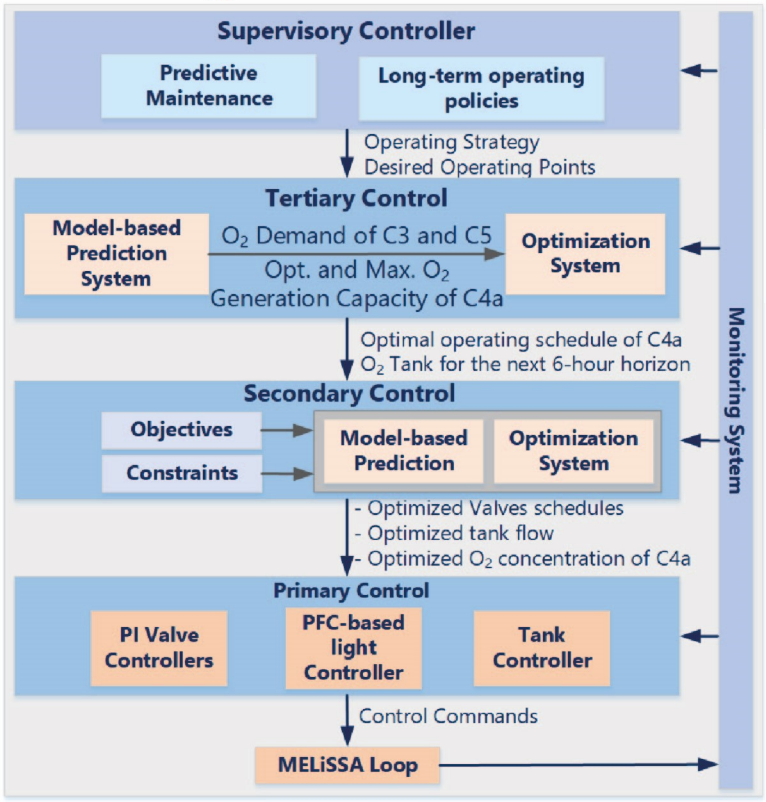
Proposal for MELiSSA Overall Control Loop Architecture

C. Ciurans, N. Bazmohammadi, L. Poughon, O. Gerbi, J.C. Vasquez, JM. Guerrero, CG. Dussap, F. Gòdia

A novel hierarchical control structure (HCS) inspired by analog control problems found in Microgrids and large-scale process industries is proposed to operate and control Closed Ecological Systems (CES). The study focuses on the optimal control and operation of the MELiSSA Pilot Plant (MPP) at its current integration phase following a three-layered HCS. A case study is simulated in which nitrogen load in C3 is modified in order to force the HCS to adapt the process operating conditions to guarantee crew safety

Methodology



Tertiary Controller: Guarantees long term performance by providing optimal references

$$J_{TC} = \min_{Q_{TC}} \sum_{k=0}^{Nc_1-1} \left(Q_{TC} - Q_{ref,TC}(i+k|i)\right)^2$$

$$\sum_{cons} D_{TC}(i+k|i) = \sum_{prod.} Q_{TC}(i+k|i) + \sum_{storing} B_{TC}(i+k|i)$$

Secondary Controller: A concensus decision is made between: Tertiary Controller commands, overall setpoint-tracking and rate of change penalization

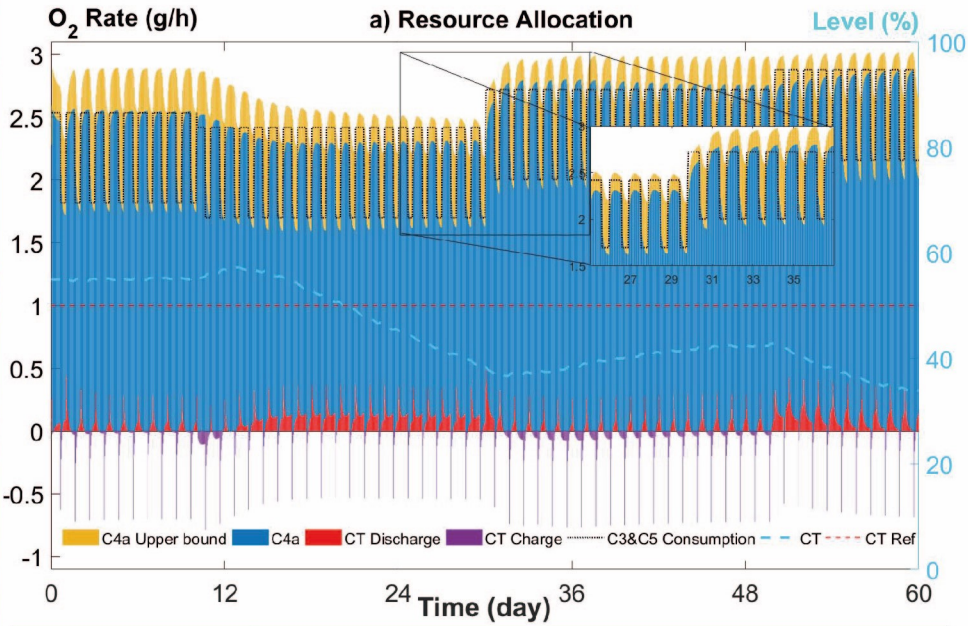
$$J_S = \min_{U_{SC}} (\lambda_1 J_{SC1} + \lambda_2 J_{SC2} + \lambda_3 J_{SC3})$$

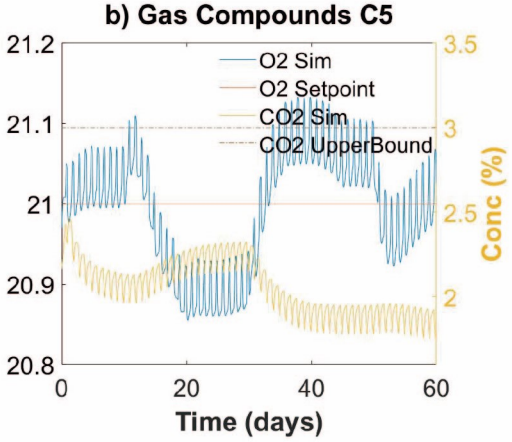
$$J_{SC1} = Penalization\ SP\ track\ offset$$

$$J_{SC2} = Penalization\ 3ary\ Controller\ offset$$

$$J_{SC3} = Penalization\ rate\ of\ change$$

Simulation





N Load (mg N L^{-1} d^{-1})	Value	Nominal parameter	Value
Load1*	435	Light (day)	225 W/m^2
Load2	343	Light (night)	84 W/m^2
Load3	580	CT Ref	50%

C. Ciurans, N. Bazmohammadi, JC. Vasquez, CG. Dussap, JM. Guerrero, F. Gòdia, "Hierarchical Control of Space Closed Ecosystems-Expanding Microgird Concepts to Biological Architectures," IEEE Industrial Electronics Magazine, Accepted on 8 Sep. 2020.

Conclusions

- Coordination of multiple consumer/producer compartments
- Optimal resource allocation
- Smooth response to transient behaviour