Advanced Energy Management Systems for Energy Storage Management in Data Centers: The DATAZERO 2 Approach

Panel Session: “Innovations on Smart Energy Storage Systems and Integration in Power Systems”

IEEE PES General Meeting – July 2021

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Datacenters and renewables

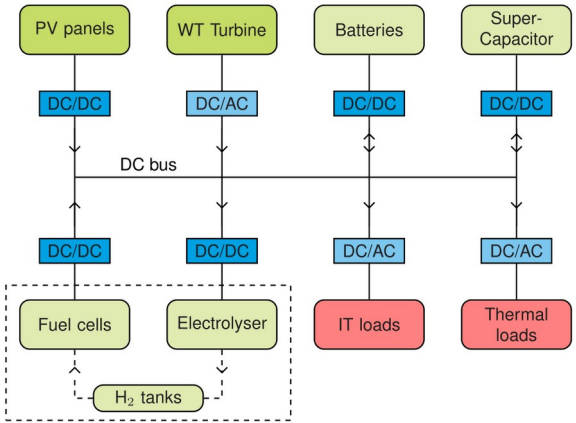
- Datacenters worldwide consume about 200 TWh/y (IEA)
- How to decarbonize IT and datacenters?
- Variable renewables are part of the solution
- Reliability requirements of datacenters are very high: 99.xxx% availability
- So how to ensure 100% renewable/local supply AND reliability?
- A part of the answer is in storage

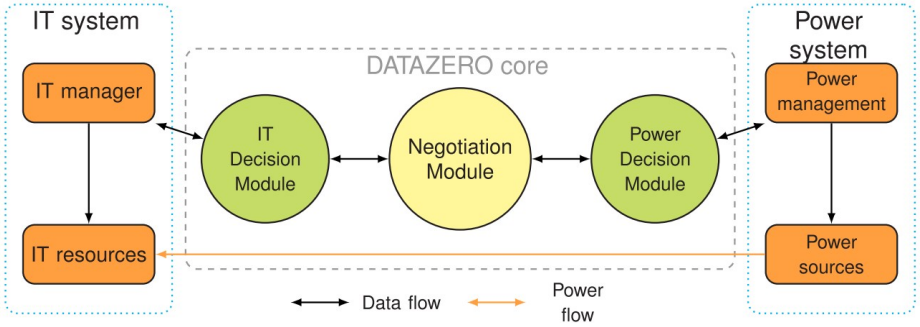
The DATAZERO projects

- Funding: French research agency ANR
- Partners: 3 laboratories (IRIT, LAPLACE, FEMTO-ST), EATON
- Goal: design a 1 MW datacenter supplied with 100% local renewables
- Strategy: use power supply and IT load flexibilities through negotiation
- Two projects: DZ1 (2015-2019), DZ2 (2020-2024)
- No demonstrator, small-scale demonstration of selected aspects

DZ1: Simulation architecture

- Supply: PV, wind turbines, batteries + hydrogen
- Modules: power decision, IT decision, negotiation
- Middleware to enable interactions between modules





DZ1: Sizing / Energy management

- Sizing of power supply equipment
  - Analytical method
- Energy management (scheduling)
  - MILP-based method – Cost function?
  - Follows yearly H_2 trend
- Limits of the above
  - Does not deal with uncertainty, absorbed by storage
  - No direct use of IT flexibility (DR), uses negotiation
  - Reliability not considered, ageing issues ignored
  -

$$\text{Minimize } |Pload_u - (Pwt_u + Ppv_u + (Pfc_u + Pdch_u)\eta_{inv} - (Pez_u + Pch_u)\eta_{inv})| \quad (15)$$

$$\text{Subject to: } Pload_u \leq Pwt_u + Ppv_u + (Pfc_u + Pdch_u)\eta_{inv} - (Pez_u + Pch_u)\eta_{inv} \quad (16)$$

$$SOC_u = (1-\sigma)SOC_{u-1} - \frac{Pdch_{u-1}}{\eta_{dch}}\Delta t + \eta_{dch} Pch_{u-1}\Delta t \quad (17)$$

$$Pfc_u \Delta t = LHVh_2 \times Qfc_u \times \eta_{fc} \quad (18)$$

$$Pez_u \Delta t = HHVh_2 \times Qez_u / \eta_{ez} \quad (19)$$

$$LOH_u = LOH_{u-1} + Qez_{u-1} - Qfc_{u-1}/\eta_{tank} \quad (20)$$

$$\text{Bounds: } Pfc_u \leq Pfcmax \quad (21)$$

$$Pezmin \leq Pez_u \leq Pezmax \quad (22)$$

$$SOCmin \leq SOC_u \leq SOCmax \quad (23)$$

$$0 \leq LOH_u \leq LOHmax \quad (24)$$

$$Pfc_u \geq 0$$

$$Pez_u \geq 0$$

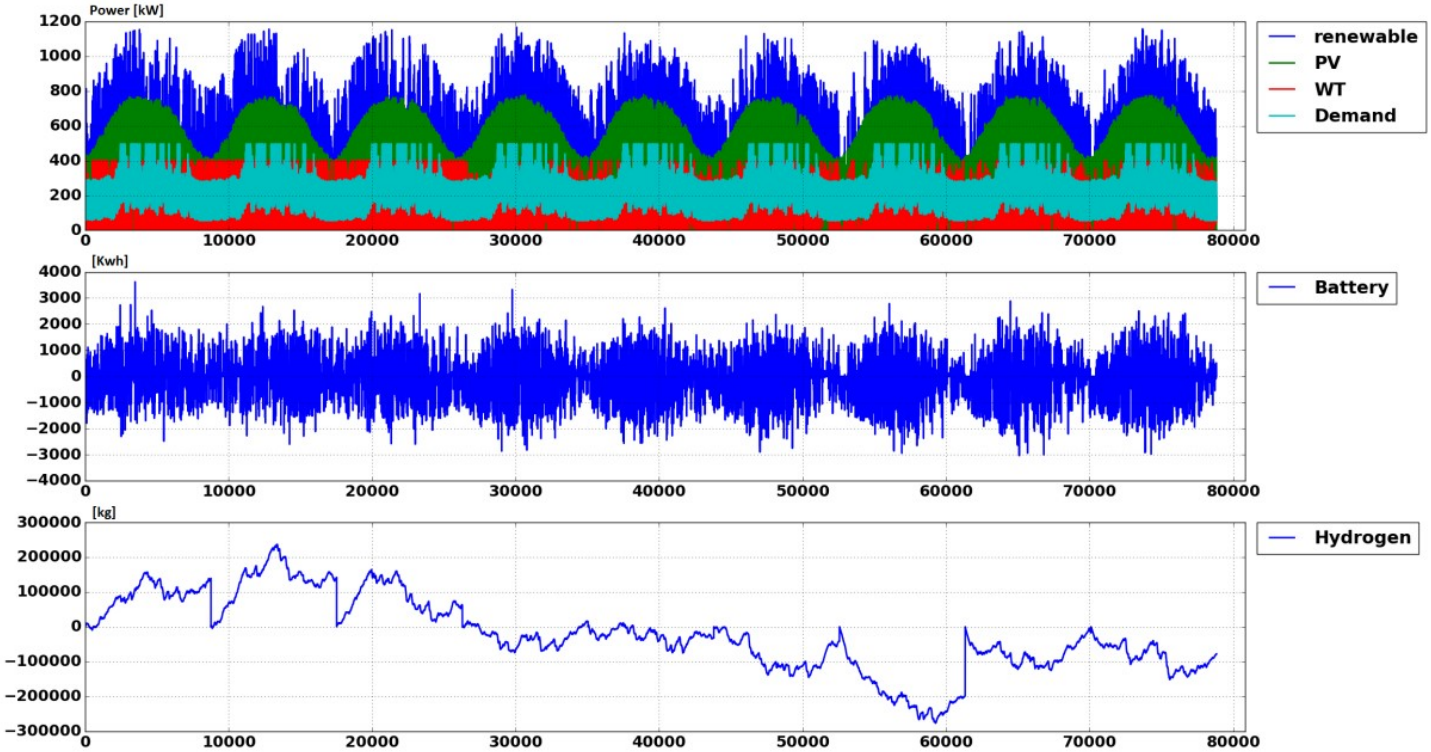
$$\text{Initial conditions: } LOH_0 = LOHinit$$

$$SOC_0 = SOCinit$$

$$Pfc_0 = 0$$

$$Pez_0 = 0$$

DZ1: Sizing / Energy management



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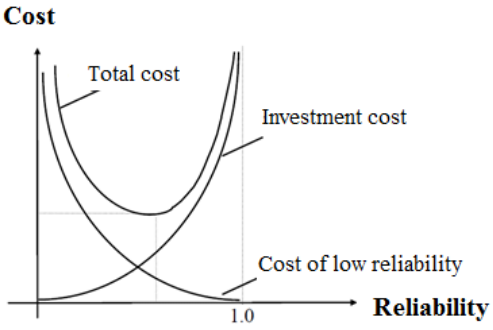
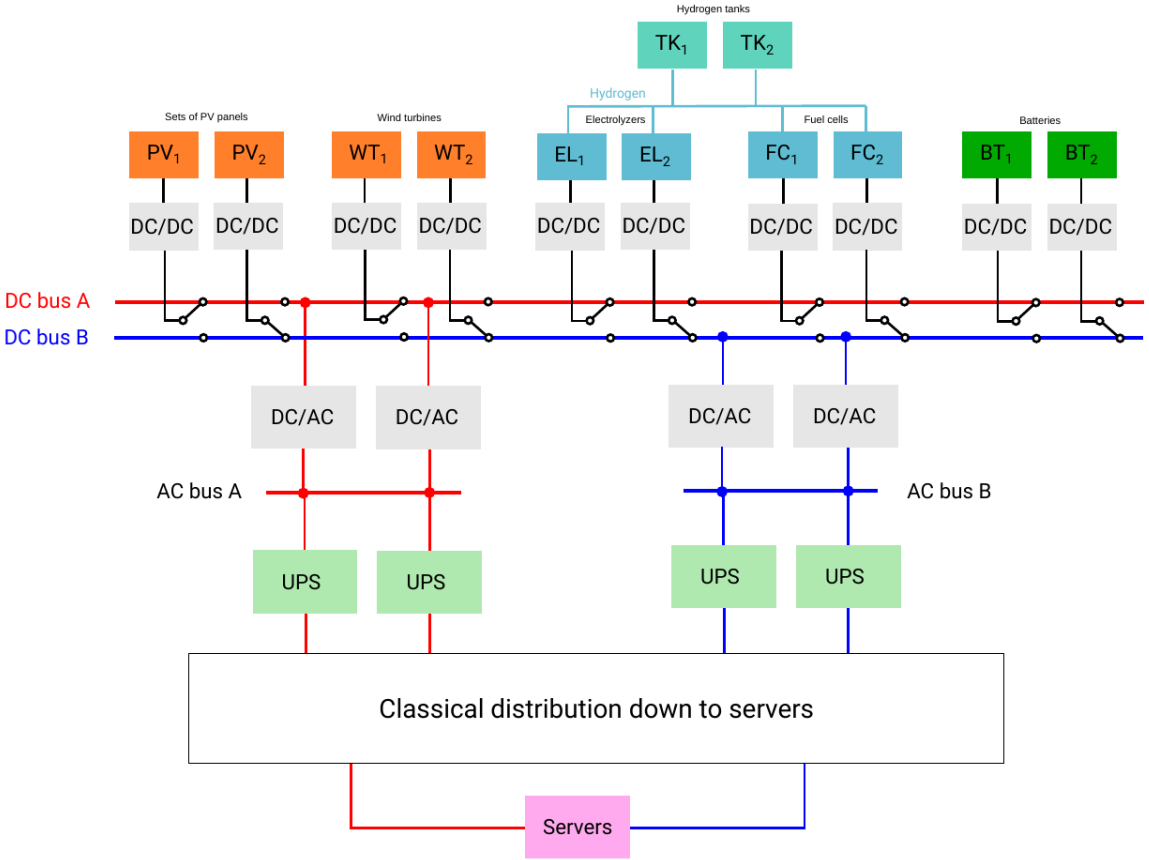
DZ2: Toward a new architecture

- Uncertainty sources: weather, load, failures – Reliance on forecasts and attached errors
- How to deal with this?
  - Oversizing: high capital costs, under-used assets. How to avoid this?
  - Managing risk: what threshold? Which method?
- Proposed solution:
  - Use several components of the same type to limit oversizing (next slide)
  - Use two feeds for reliable and fast response: dynamic reconfiguration is necessary
- Impacts on sizing and scheduling: how many components of each type? How to manage ageing/reliability?
- How to quantify reliability in this case? Do tiers or 2N, 2N+1, etc. still make sense?




Hydrogen tanks
TK1
TK2
Hydrogen
Electrolyzers
Fuel cells
Sets of PV panels
Wind turbines
Batteries
PV1
PV2
WT1
WT2
EL1
EL2
FC1
FC2
BT1
BT2
DC/DC
DC bus A
DC bus B
DC/AC
AC bus A
AC bus B
UPS
Classical distribution down to servers
Servers

DZ2: Next steps on these topics

- Finalize architecture design
- Model it, define reliability estimation methodology
- Enable dynamic reconfiguration with both feeds
- Adapt sizing and scheduling methods, consider IT flexibility
- Full simulation of the datacenter, test on use cases
- Validation on PHIL testbench
- Mutualize batteries with UPS?

Thank you

Acknowledgments: ANR, DZ1 + DZ2 participants

For more information on DZ1: DOI: 10.1109/ACCESS.2019.2930368

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