Comparison of AC, DC, and AC/DC Bus Configurations for PV Hybrid Systems

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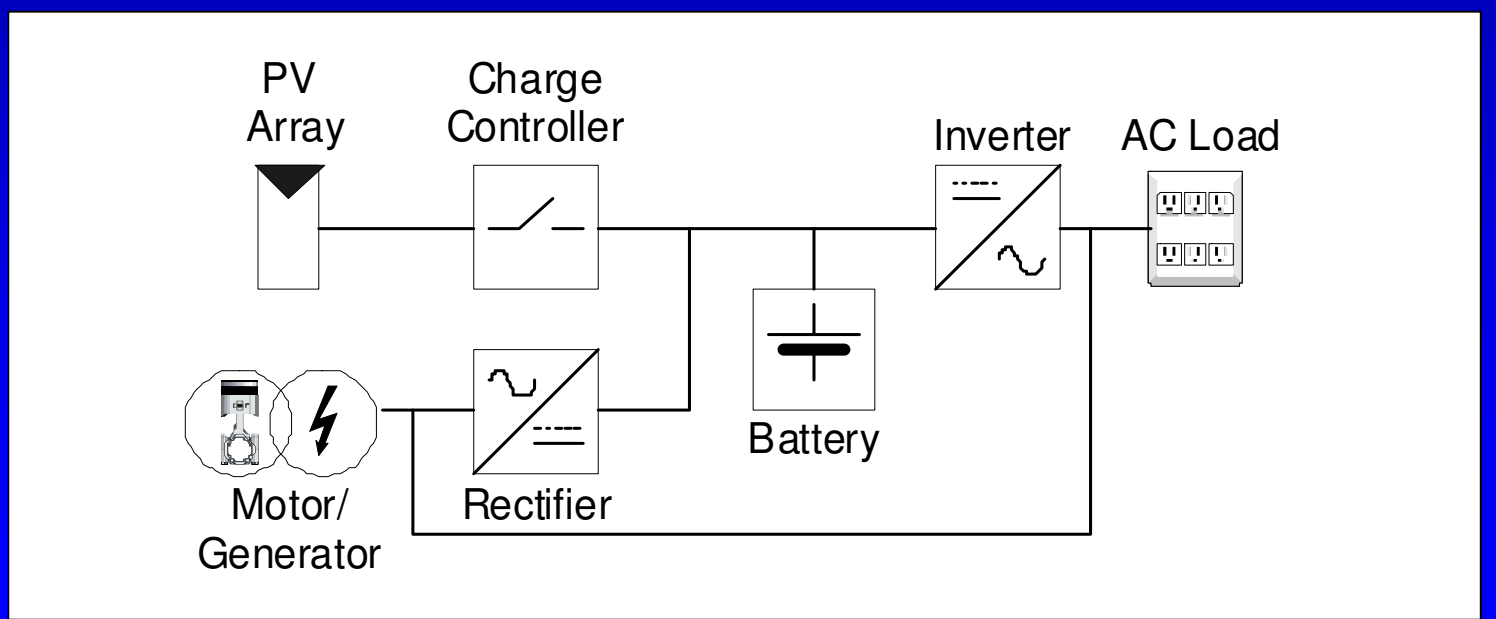
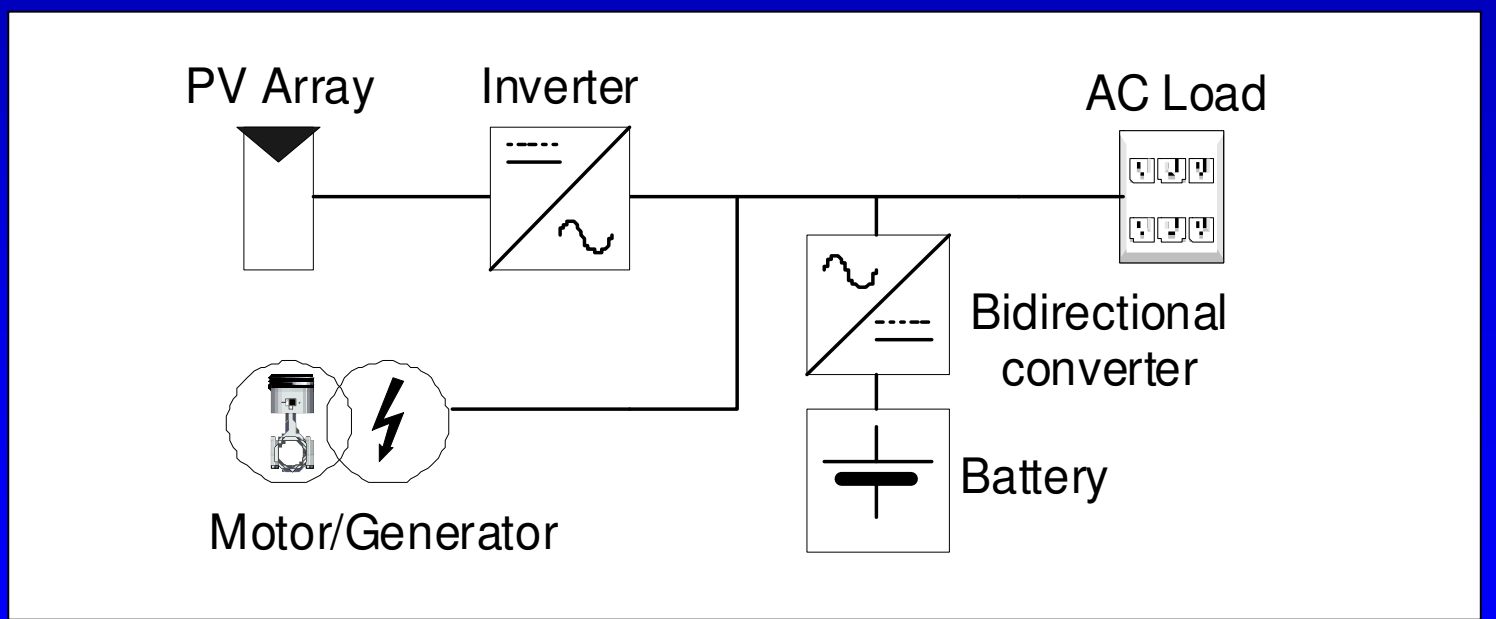
AC/DC bus configuration is typical in Canada

- PV <-> battery connection is DC
- Genset can supply loads directly



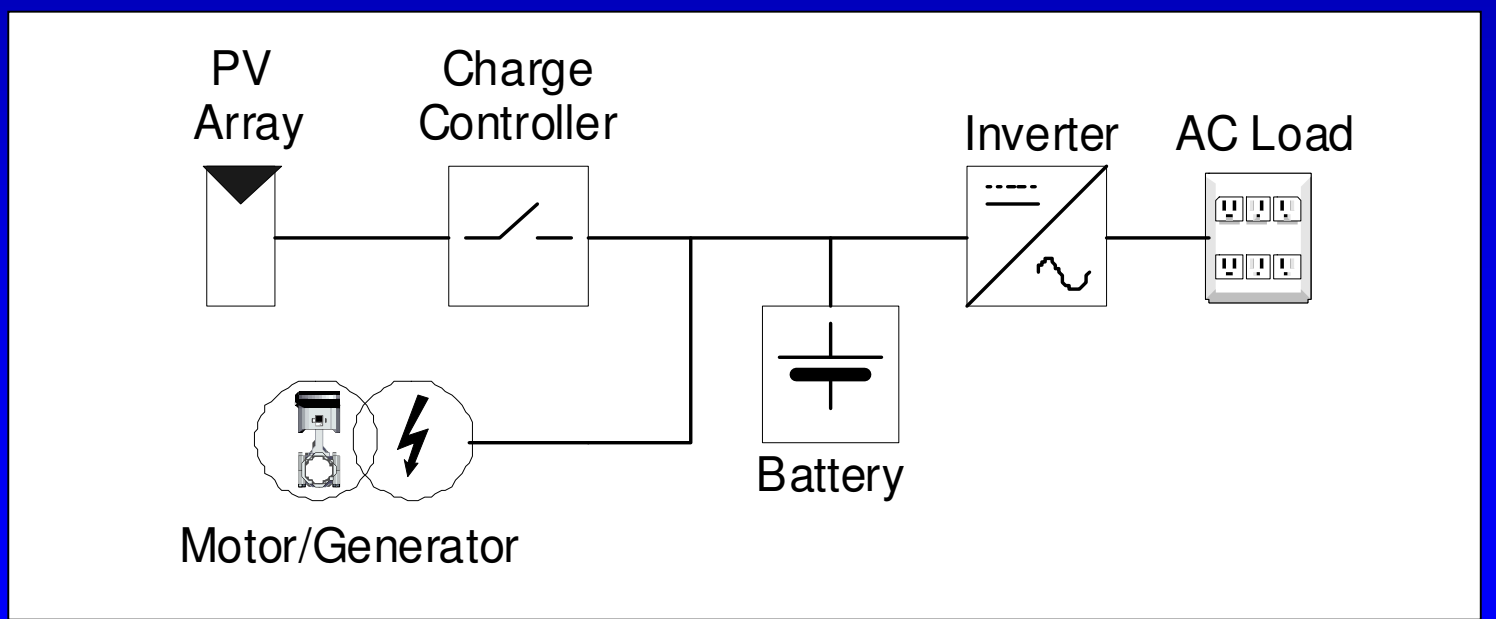
AC bus is being promoted in Europe

- Module or string inverters at array
- Modularity and flexibility– can just add more modules
- But two conversion stages between array and battery



DC bus on the horizon?

- DC output of genset permits variable speed operation, leading to decreased fuel consumption under part load
- Genset output directly to load must pass through inverter

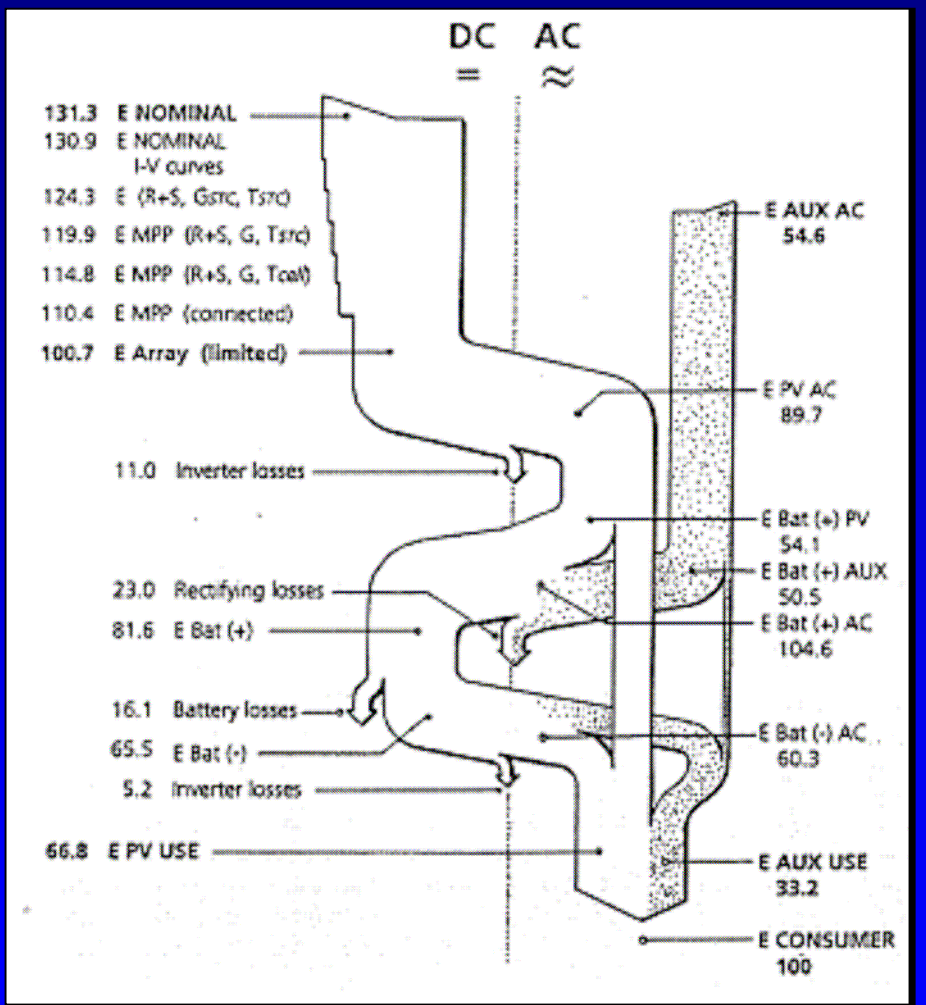


Gabler and Wiemken (1998) Study

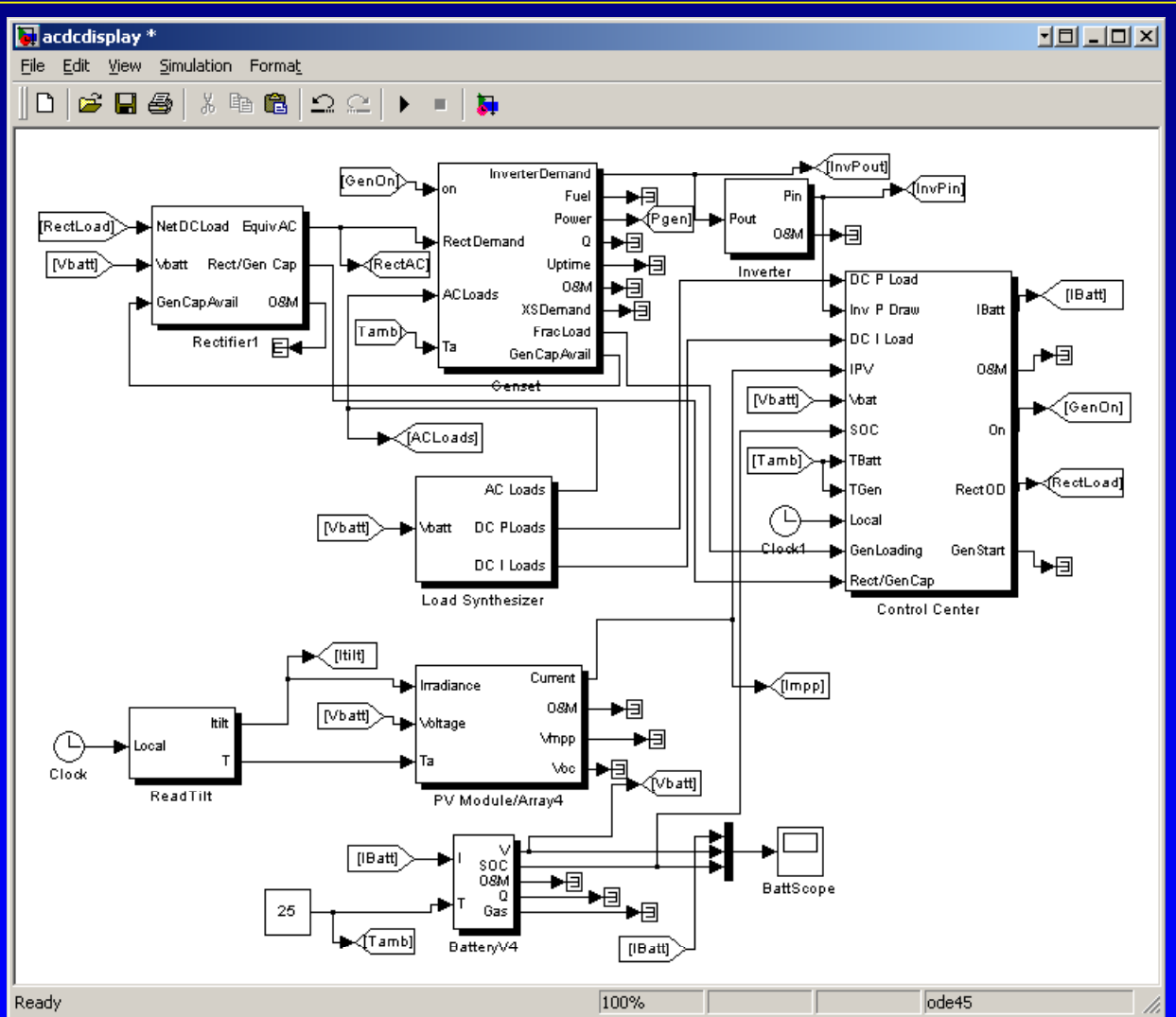
- Compared AC bus and AC/DC bus for one hybrid system in Freiburg, Germany using simulation
- “In spite of the additional transforming processes, the AC coupled system is not far away in performance”
- Solar fraction and performance ratio are only 6% lower than with AC/DC bus

Gabler and Wiemken (1998) Study

- Do not include MPPT for AC/DC bus system
- Who cares about solar fraction and performance ratio?
  - Genset fuel consumption is what counts



PVToolbox Simulation Study

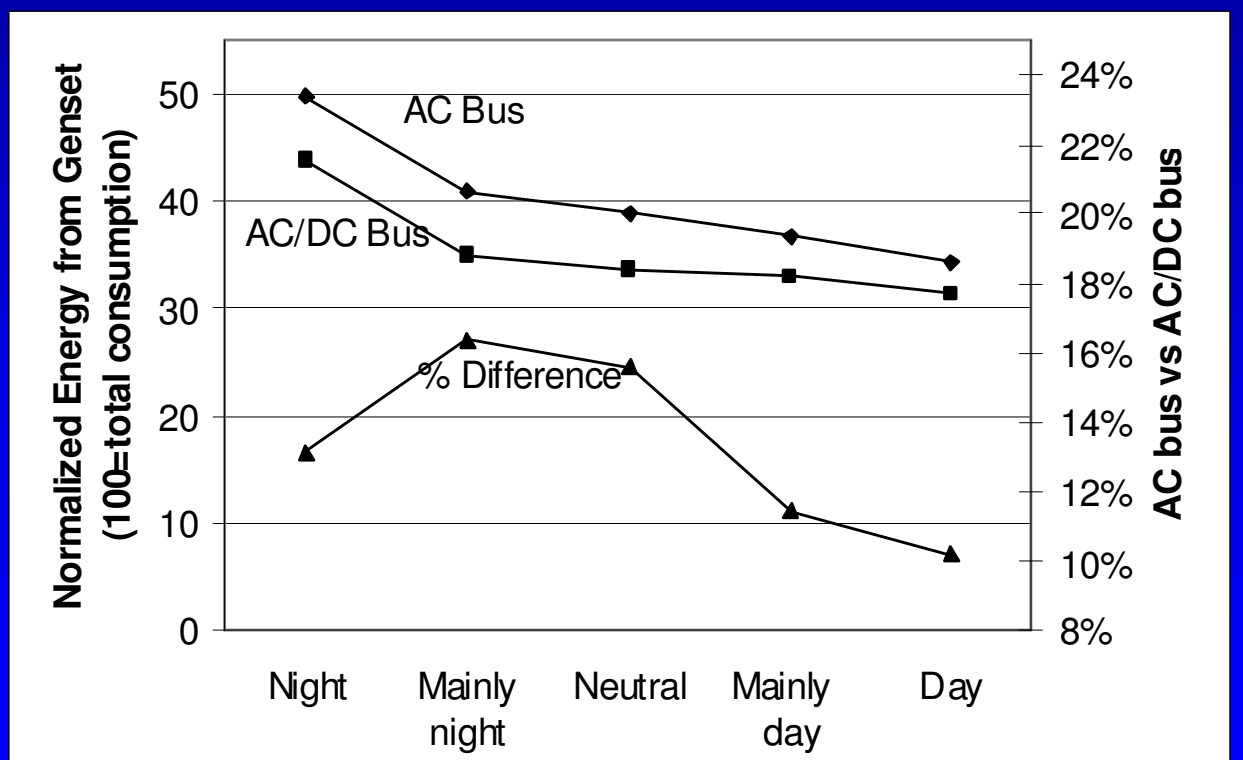


PVToolbox Simulation Study

- Recreated Gabler and Wiemken results with good accuracy
- When AC/DC bus system includes MPPT, fuel consumption of AC bus system is around 19% higher
- When rectifier efficiency improved to match efficiency of inverter, fuel consumption of AC bus system is around 12% higher

Sensitivity to Load Profile, Size of Array

- Conclusions insensitive to diurnal or seasonal variation in load profile
- Apply over entire range of array-to-load ratios



Comparison with DC bus system: Electricity

- Extended simulations to include DC bus and DC loads
- Results for electricity required from genset:

	AC/DC Bus	AC Bus		DC Bus	
	Total=100	Total=100	% Diff	Total=100	% Diff
Baseline	39.7	44.6	12.3%	40.0	0.7%
No equalisation	36.2	41.3	14.1%	37.1	2.6%
5.1 kW AC load	41.1	47.4	15.3%	42.0	2.3%
AC & DC loads	38.0	44.7	17.7%	38.2	0.5%
DC loads	36.0	42.5	18.2%	35.9	-0.3%

Comparison with DC bus system: Fuel

- Results for fuel consumed by genset:

	AC/DC Bus	AC Bus		DC Bus	
	l diesel	l diesel	% Diff	l diesel	% Diff
Baseline	844	935	10.8%	746	-11.6%
No equalisation	675	769	13.9%	693	2.7%
5.1 kW AC load	869	987	13.6%	782	-10.0%
AC & DC loads	814	938	15.2%	712	-12.5%
DC loads	776	899	15.9%	669	-13.8%

This overestimates benefit of DC bus

- DC bus system will not, in reality, achieve this level of improvement
  - Ideal variable speed genset was used; real variable gensets do not have zero fuel consumption at zero load
  - 8 hour monthly equalisation is probably longer than is necessary
- Dispatch strategy that avoids part-load operation of genset may permit AC/DC bus system to match DC bus system performance

Conclusions

- AC/DC bus configuration in common usage is just fine
- AC bus system requires 10 to 18% more fuel than AC/DC bus configuration
- DC bus system with ideal genset and very frequent equalisation consumes 10 to 14% less fuel than AC/DC bus configuration
  - Real gensets far from ideal
  - Smarter dispatch that avoids genset part load operation closes gap