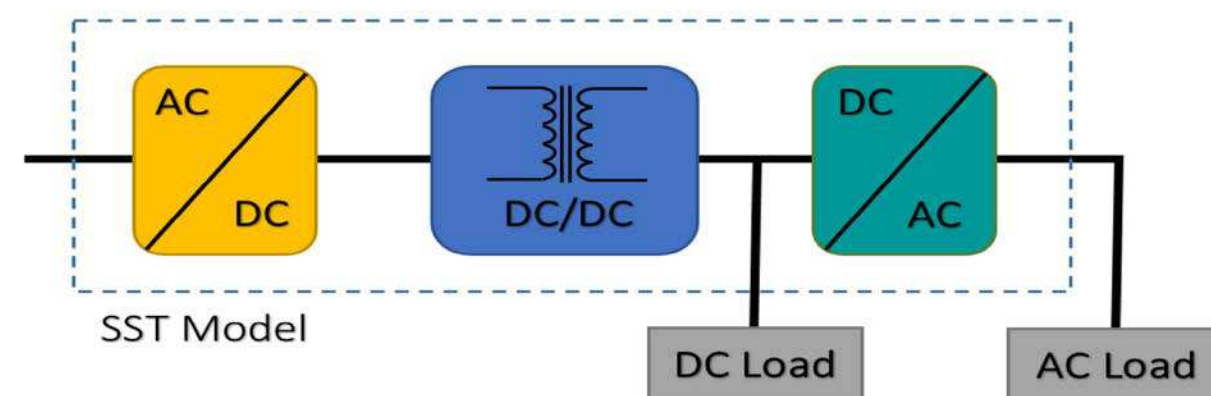


## Background

- Net-metered PV residences could save **5%** of their total electricity load for houses switching to a DC distribution system in their houses<sup>1</sup>.
- DC-internal technology residential appliances are more energy efficient compared to standard technology<sup>1</sup>.

Load Type	Energy Saving
Cooling load	36.5%
Non-cooling load	32.8%

- FREEDM can provide DC service. This benefit has not been evaluated and could potentially form the most cost effective FREEDM application

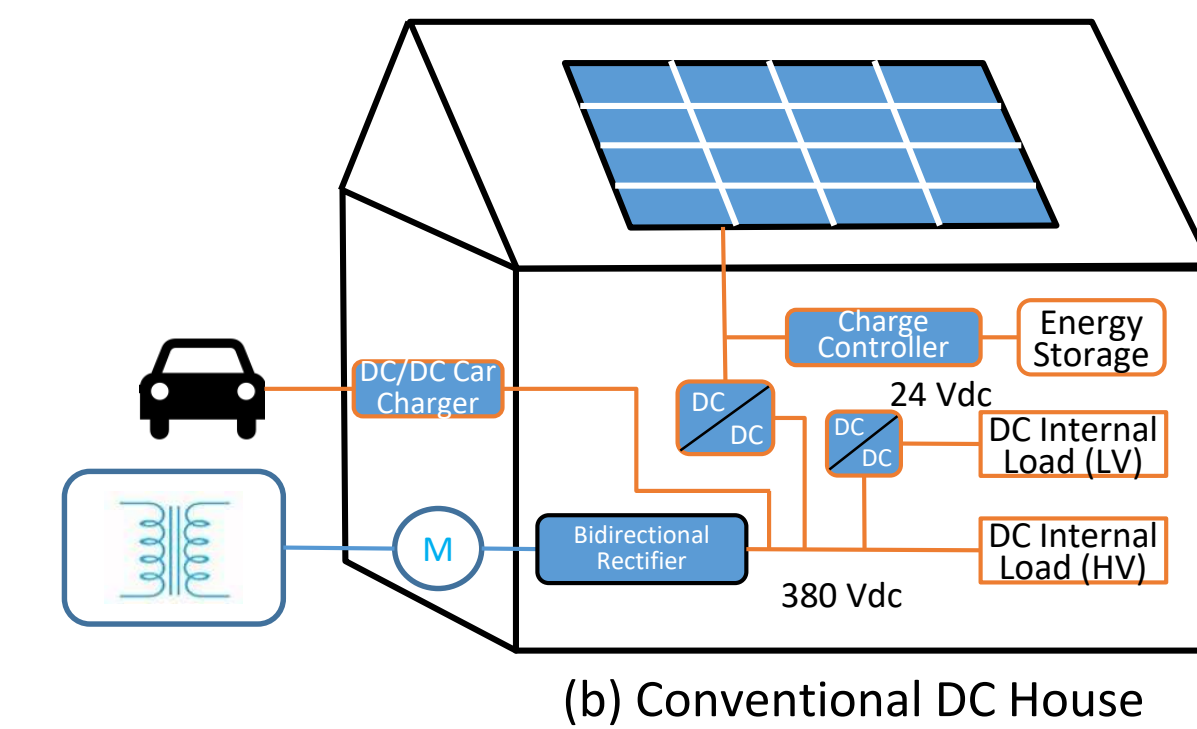
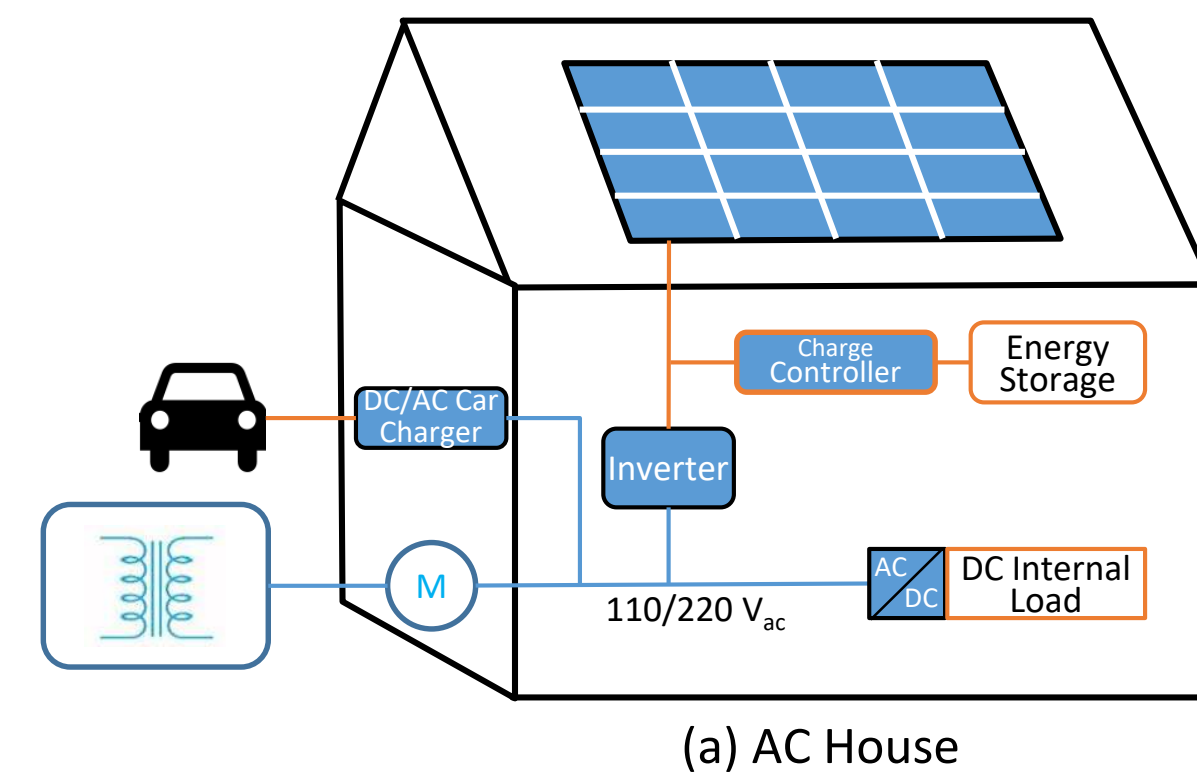


- How will FREEDM houses compare to Non-FREEDM houses?

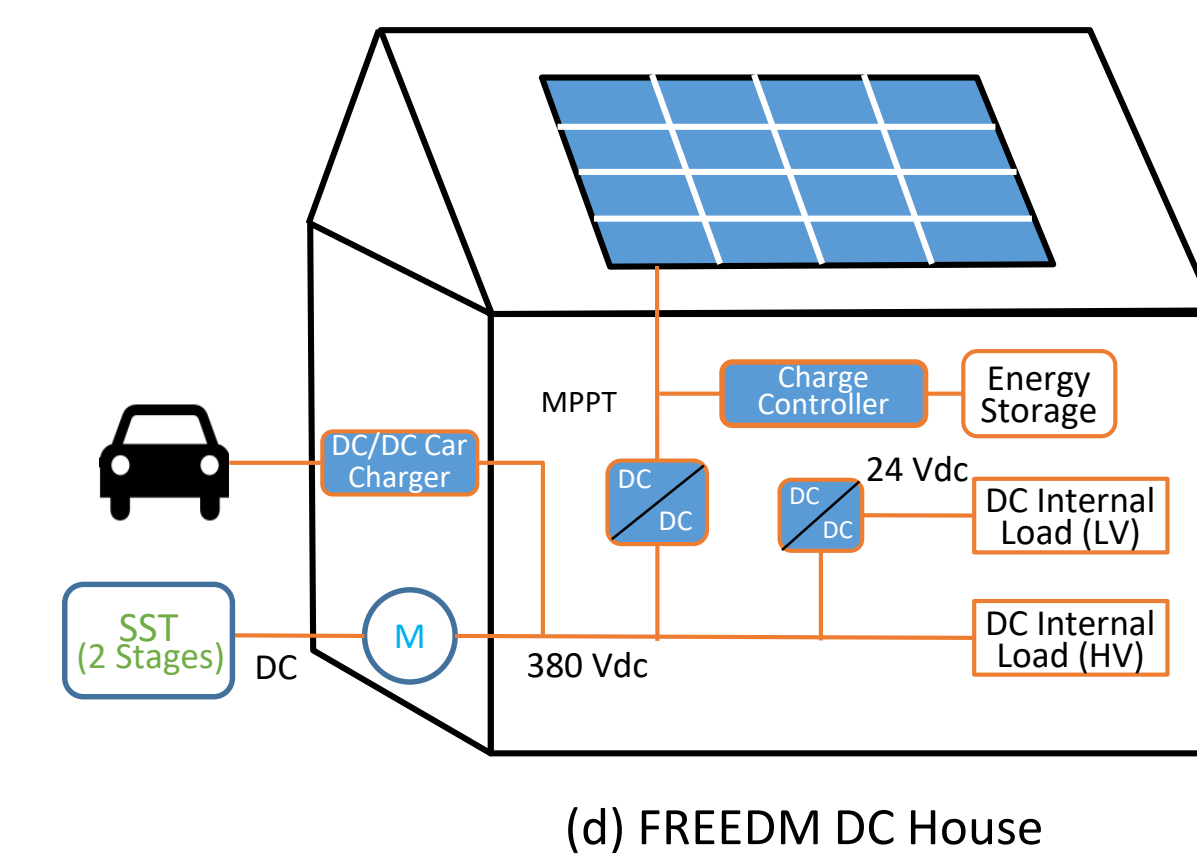
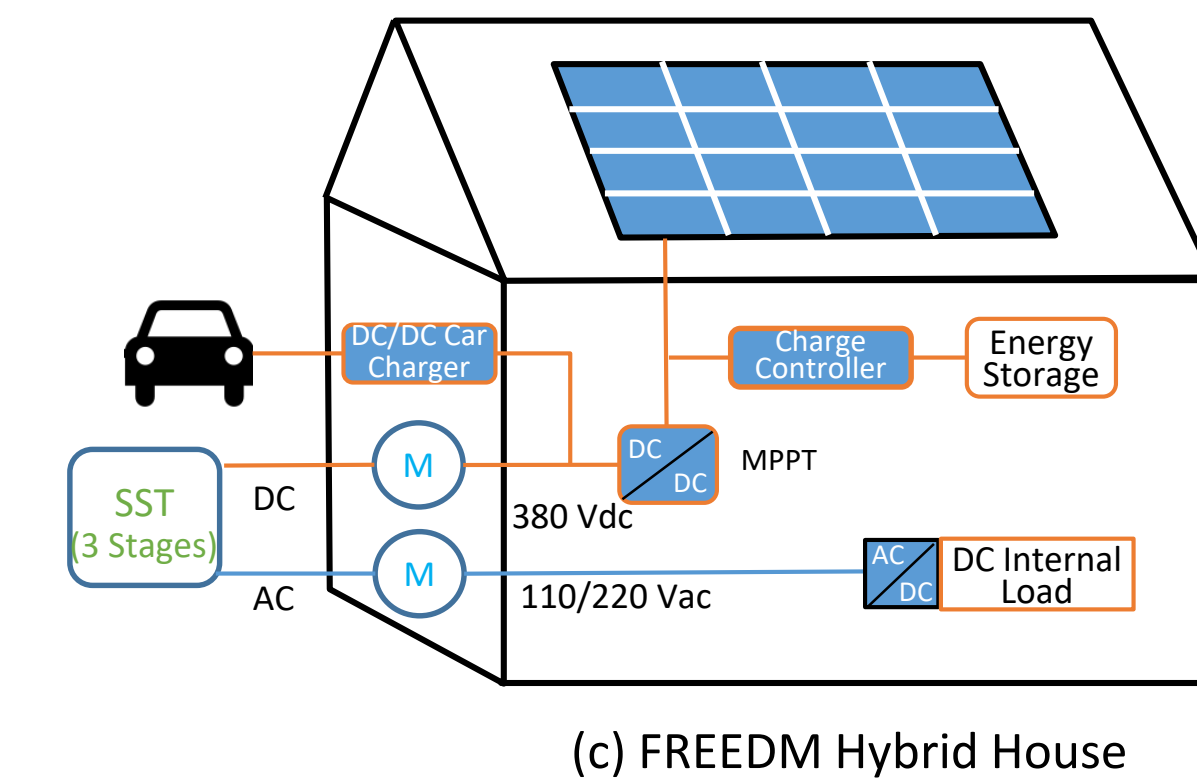
## Approach

1. Model different residential houses  
Location: NC-Wilmington  
Electric heating and cooling  
Three-tier efficiency for converters
- 
- Daily Load Curve
2. Size the PV system so the AC house is net zero energy house
  3. Calculate the losses for a year
  4. Perform cost benefit analysis for each type comparing to AC house

## House Models



Non-FREEDM  
FREEDM



## Results

- House Parameters
  - ✓ Location: Wilmington, NC
  - ✓ Total load for a year: 15 MWh
  - ✓ Switch to DC internal load: 10 MWh
  - ✓ PV system: 8 kW
  - ✓ Solar energy generated: 12 MWh-yr.
  - ✓ Electricity price: 10 cents/kWh
  - ✓ Asset life: 25 years

Note: The analysis exclude the appliance efficiency savings.

Cost Table

Devices	Size	AC House	Conv. DC	FREEDM Hybrid	FREEDM DC
Inverter	8 kVA	\$ 3,025	\$ -	\$ -	\$ -
DC/DC MPPT	8 kVA	\$ -	\$ 1,210	\$ 1,210	\$ 1,210
DC/DC 380-24V	1.5 kVA	\$ -	\$ 214	\$ -	\$ 214
Bidirectional Rectifier	5 kVA	\$ -	\$ 620	\$ -	\$ -
<b>Total Cost Above</b>		\$ 3,025	\$ 2,044	\$ 1,210	\$ 1,424
<b>SST Cost</b>	\$/year	\$ -	\$ -	\$ 82.0	\$ 54.6
	or \$/month	\$ -	\$ -	\$ 6.8	\$ 4.6
<b>Total Energy losses (MWh/yr.)</b>		2.24	2.09	1.62	0.75

Comparative Analysis

Comparing to AC House	Conv. DC	FREEDM Hybrid	FREEDM DC	
<b>Device Saving (Year 0)</b>	\$ 981	\$ 1,815	\$ 1,601	
<b>SST Cost per Year (\$)</b>	\$ -	\$ 82	\$ 55	
<b>Energy Saving per Year</b>	MWh/yr.	0.15 MWh	0.61 MWh	1.49 MWh
	%	1.3%	5.4%	13.1%
<b>Saving per Year (\$)</b>	\$ 14.7	\$ 61.4	\$ 148.6	
<b>Saving NPV</b>	\$ 1,115	\$ 1,628	\$ 2,454	

## Conclusion and Next Steps

- Conclusions
  - ✓ DC House is more energy efficient than AC House.
  - ✓ FREEDM House is more efficient than non-FREEDM house.
- Next Steps
  - ✓ Combine the appliance efficiency savings into the study.
  - ✓ Perform a comprehensive cost benefit study for customers.
  - ✓ Include the impacts of new technologies like energy storage and electric vehicles.
  - ✓ Research new tariff policy like a FREEDM DC service package which may lead to win-win for both the utility and customers.

## References

1. K. Garbesi et al., "Optimizing energy savings from direct-DC in U.S. residential buildings" LBNL, 07/2012
2. L. Sun, J. Thomas, S. Singh, D. Li, M. Baran, D. Lubkeman, J. DeCarolis, A. Queiroz, L. White, S. Watts, "Cost-benefit assessment challenges for a smart distribution system: a case study" 2017 IEEE PESGM (Accepted)

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