Renewable Electric Storage Program

Preliminary Results and Findings

RU LESS - DNV·GL

06/03/2016

Agenda

- **Overview**
- **Study synopsis**
- **Model inputs**
  - EDC billing structure
  - Customer segments and load characteristics
  - DER configurations, ES cost structure
- **PV-ES economics; Preliminary results and findings through illustrative examples**
  - Value of ES across different applications
  - Value of different ES configurations in different applications
  - Effect of customer load characteristics on PV-ES economics
  - Effect of EDC cost structure on PV-ES economics
  - PV-ES resiliency benefits vs. reduced NPVs (importance of state incentives)
- **Conclusion of results**

Study synopsis

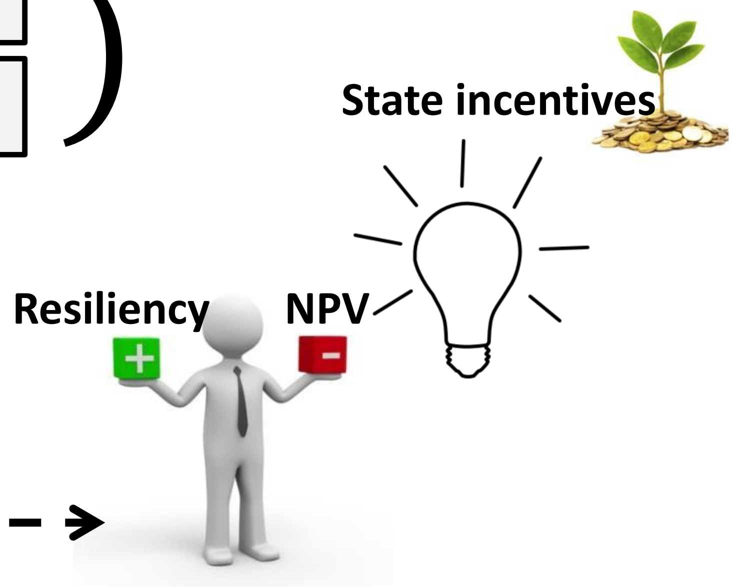
Metrics proposition for incentive level: NPV/kW or kWh

NPV is not a simple function of ES size

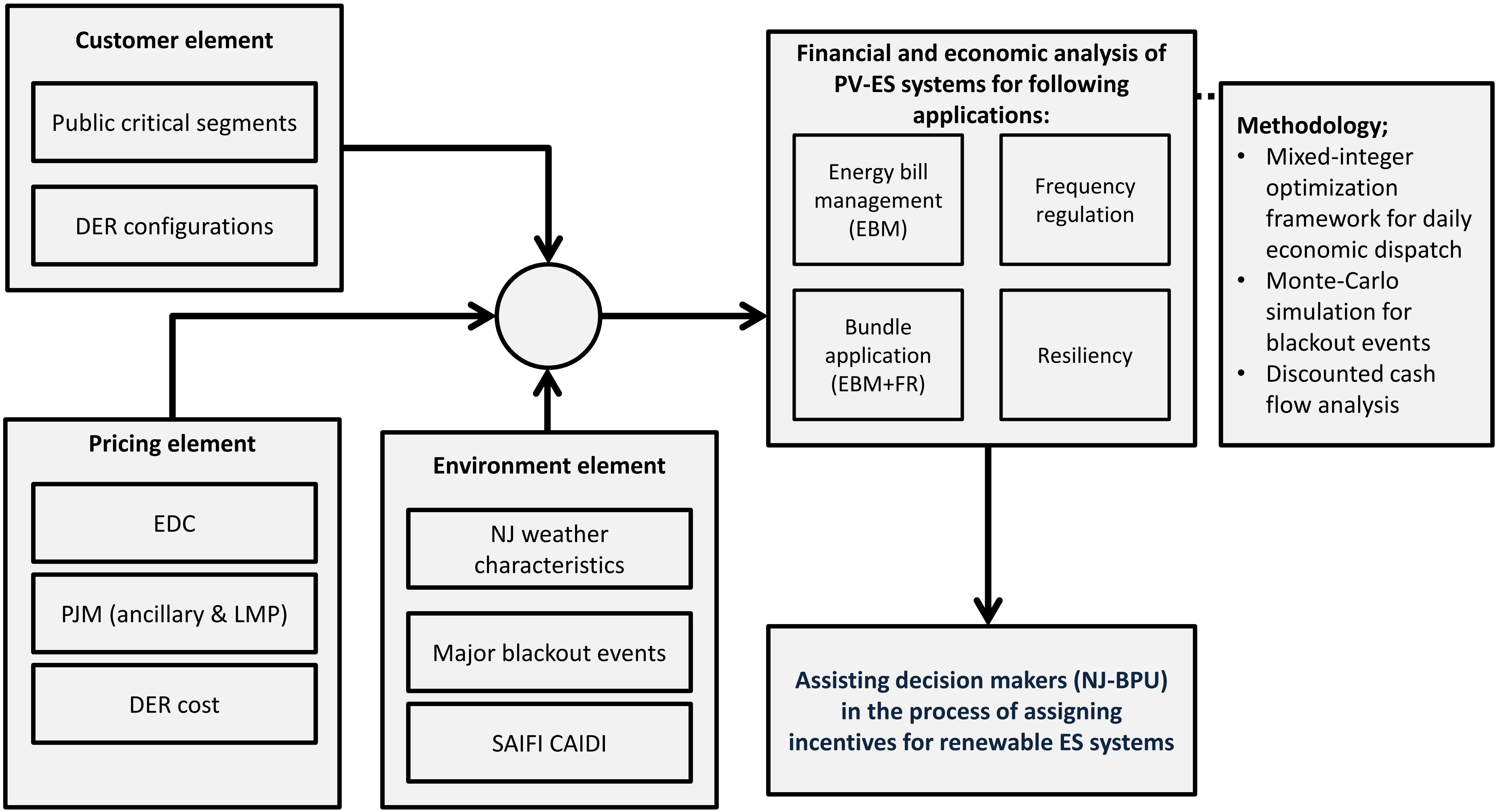
f (DER sizing | EDC billing structure | ES application | Customer load characteristics)

ES application:

- Energy bill management (EBM)
- Frequency regulation
- Bundle application (EBM+FR)
- Resiliency



Overview; model inputs, methodology, and objective



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EDC billing structure

- EDC billing components:
  - Delivery charges (kW and kWh for ☼❄)
    - Assumption: All customers have elected Rider BGS-CIEP and will be charged according to PJM LMPs for kWh
  - Supply charges (kW and kWh for ☼❄)
  - Three EDC's are considered in this study:

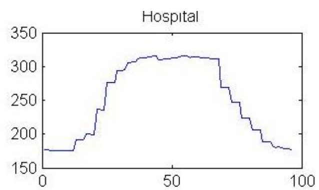
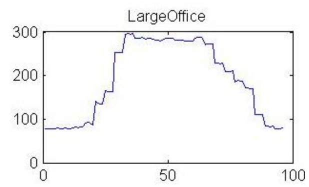
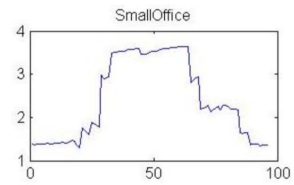
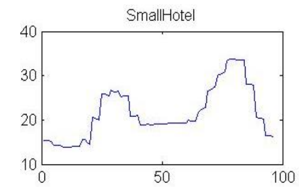
EDC1	EDC2	EDC3
• Different demand charge levels for different PSL	• Different demand charge levels for different PSL	• Demand charge is not sensitive to PSL
• Seasonal flat demand charge for PSL < 150 kW	• Seasonal flat demand charge	• Seasonal flat demand charge
• Seasonal TOU demand charges for PSL> 150kW	• Higher demand charges for PSL> 750kW	

EDC ranks

kWh charges: EDC1 < EDC2 < EDC3

kW charges: EDC1 > EDC2 > EDC3

Customer segments, and load characteristics

Hospital	Large office	Small office	Small hotel
Annual consumption: 8,800 mWh	Annual consumption: 6,700 mWh	Annual consumption: 84 mWh	Annual consumption: 757 mwh
AVG daily load profile	AVG daily load profile	AVG daily load profile	AVG daily load profile
			

Load differentiation

Hospital	Large office	Small office	Small hotel
Prolonged peak hours	***High load level***; similar load shape to small office	***Low load level***; similar load shape to large office	Different load shape; "***after hours" peak***

Emergency functionality

Load data, DER configuration, and ES cost structure

-  load time-series: simulated data using DOE EnergyPlus (Weather file : NJ)
- 

load: Fixed portion of each end-use e.g., 80% of cooling, 40% of lighting, and etc.
- 

configuration
  - PV production level as a % of total consumption (80 %)
  - ES Power rate: percentage of peak critical (50, 100 %)
  - ES duration (.5,1,1.5,…,5hrs)
- 

elements:
  - Factory cost (400 $/kWh)
  - Installation cost (47% of factory cost)
  - Invertor cost (300 $/kW)
  - Fixed O&M (18 $/kW)

Value of ES across different applications

CF Value of ES in different applications averaged over all scenario, all segments **(all percentages are against *base scenario* where PV is only available; *NO ES*)**

- On average *bundle* application provides *the highest cash flow* among all the applications

Average growth in annual cash-flow ($) vs. base scenario

Bundle	EBM	FR
34%	26%	29%

- Impact of EDC rate structure on cash flow values; *peak demand charge* is the *major* player in PV-ES systems *cash flows*

Average growth in annual cash-flow ($) vs. base scenario

EDC 1			EDC 2			EDC 3		
Bundle	EBM	FR	Bundle	EBM	FR	Bundle	EBM	FR
44%	35%	32%	**37%**	16%	34%	**22%**	15%	21%

kWh charges: EDC 1 < EDC 2 < EDC 3

kW charges: EDC 1 > EDC 2 > EDC 3

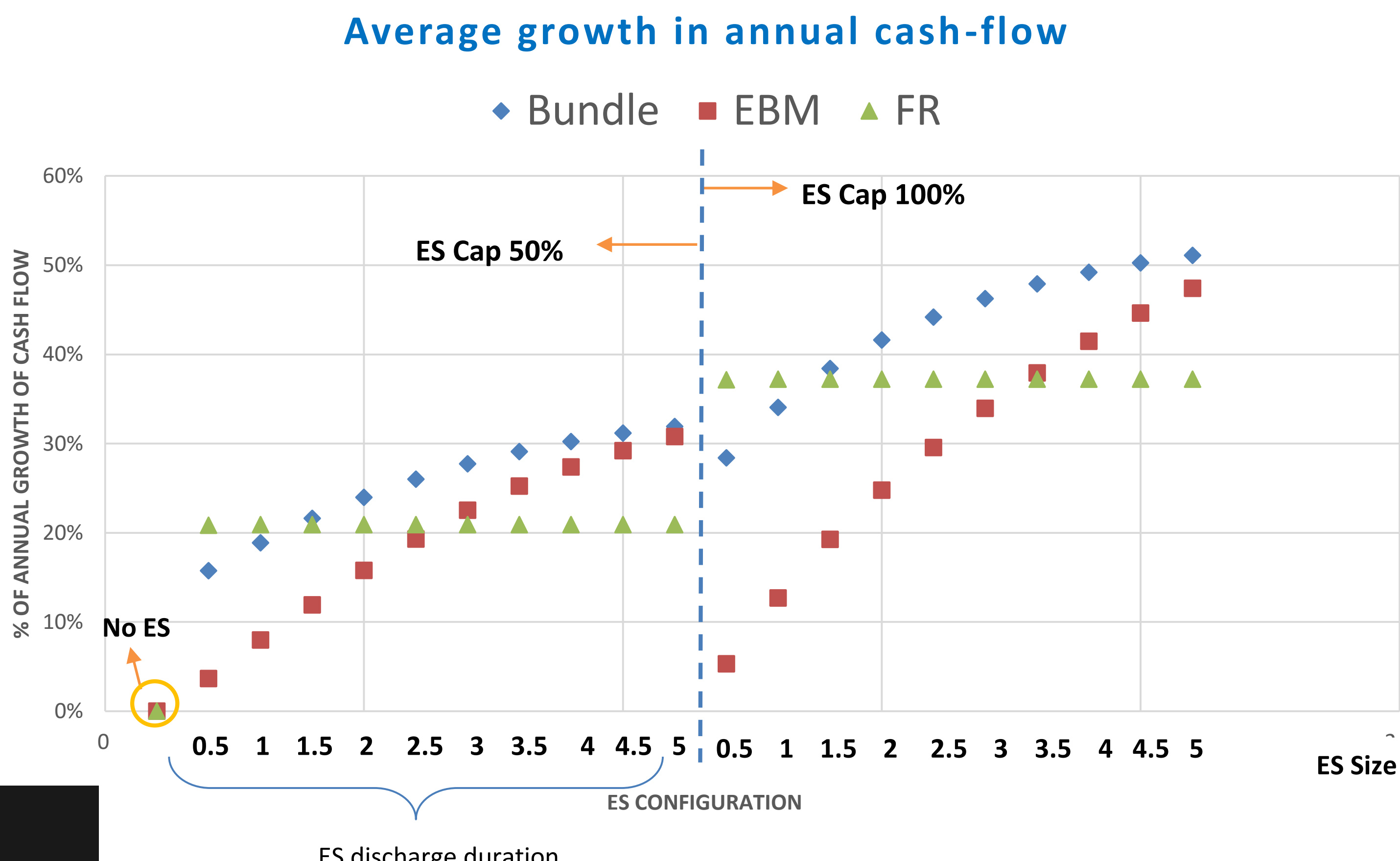
Same order as in kW charges, not kWh

Average energy and peak demand saving in bundle application vs. base

Growth in energy saving (%)	Growth in peak demand saving (%)
6%	**25%**

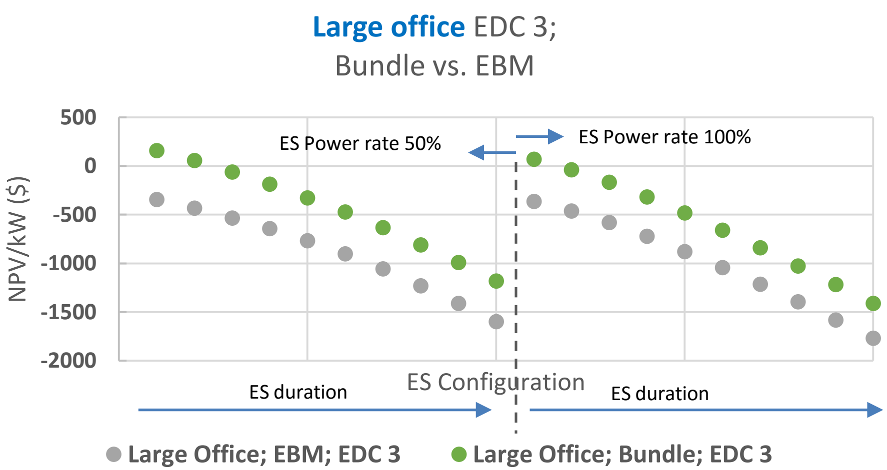
CF Value of different ES configurations in different applications averaged over all EDCs, and segments

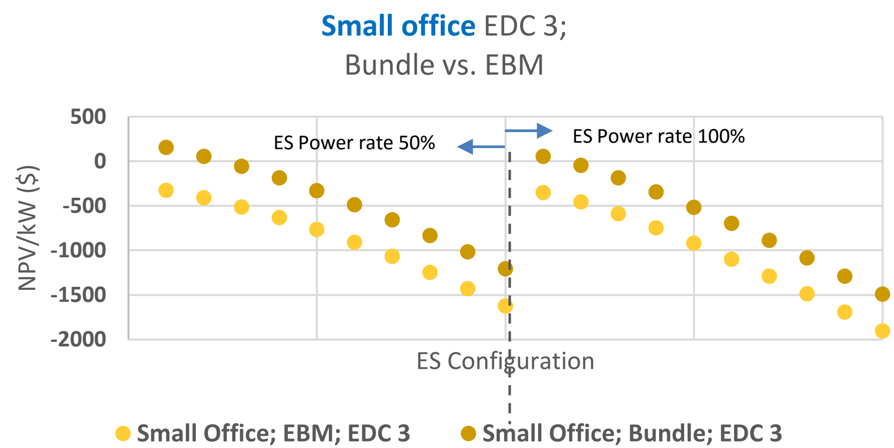
- On average *<u>Bundle</u>* application provides *<u>the most cash flow</u>* among all applications
- On average *<u>low discharge durations</u>* ($\lesssim 1$ hr), *<u>FR</u>* provides *<u>the most cash flow</u>*
- On average *<u>high discharge durations</u>* ($\gtrsim 5$hrs), *<u>Bundle</u> and <u>EBM CF converges</u> toward each other*

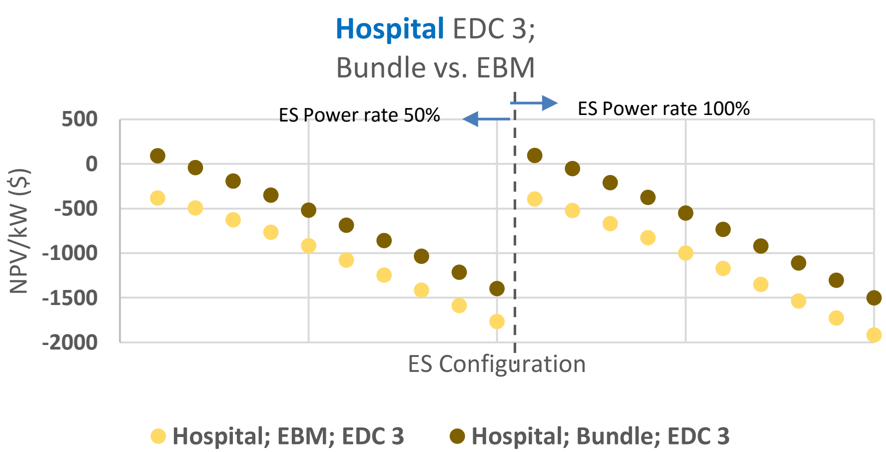


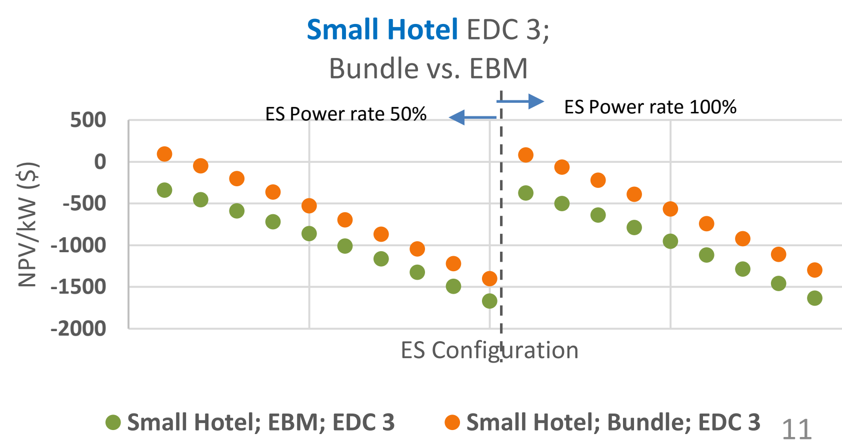
NPV Value (5yr. horizon) of different ES configurations in bundle application and EBM for all segments

- Bundle application provides higher NPV/kW compared to EBM
- Increasing the duration of ES results in less NPV/kW because of the higher investment cost









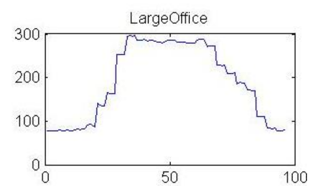
Effect of customer load characteristics on PV-ES economics

Effect of load level on PV-ES economics (NPV/kW in 5 yr. horizon)

- Small office V.S. Large office:

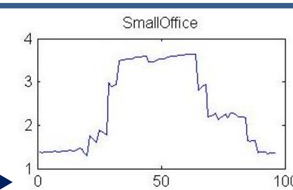
Large office
Annual consumption:
6,700 mWh

AVG daily load profile →

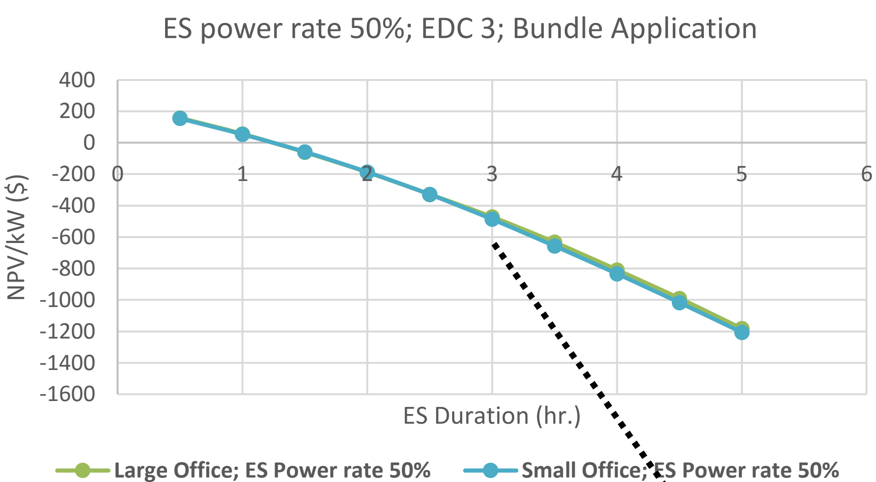


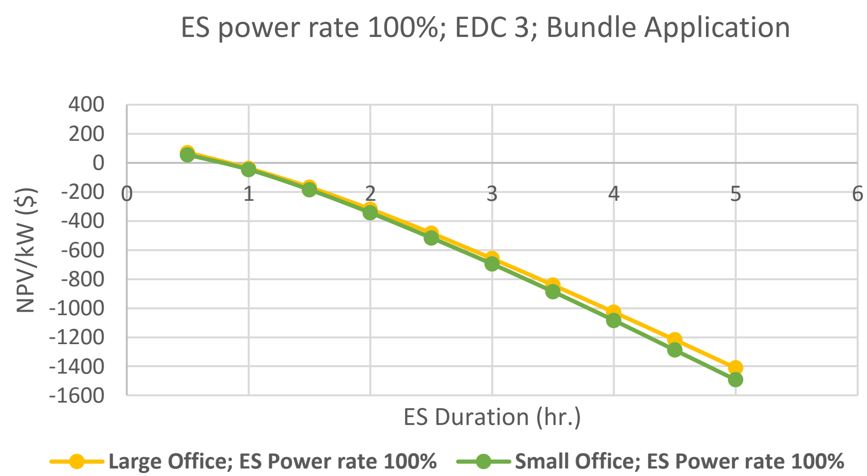
Small office
Annual consumption:
84 mWh

AVG daily load profile →



- *Similar electricity load shape with different load levels* results in *close NPV/kW*





~ 3% difference in NPV/kW

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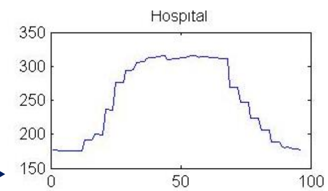
Effect of load shape on PV-ES economics (NPV/kW in 5 yr. horizon)

- Large office V.S. Hospital:

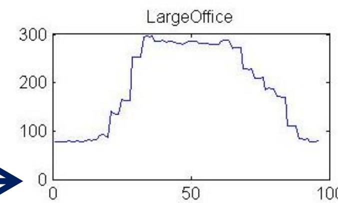
Hospital
Annual consumption:
8,800 mWh

AVG daily load profile →

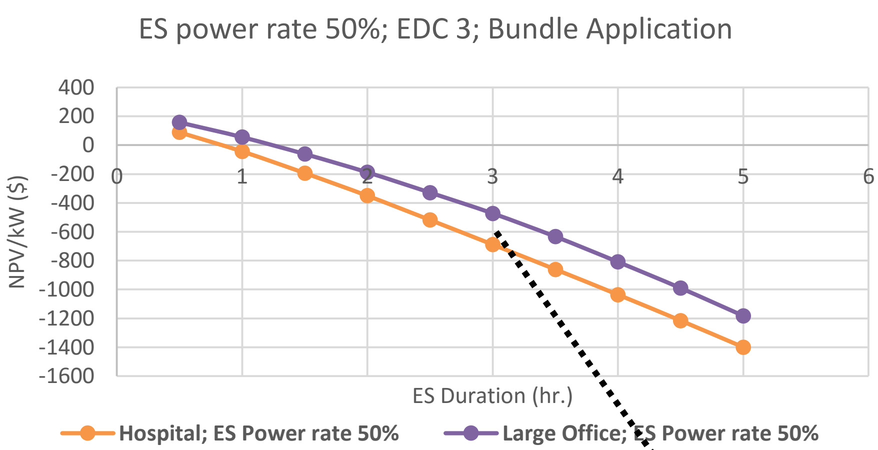


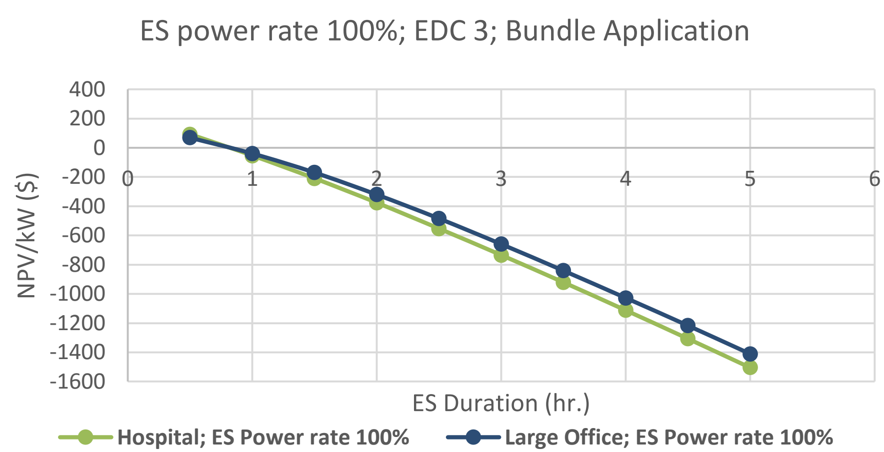
Large office
Annual consumption:
6,700 mWh

AVG daily load profile →



- Load shape may significantly influence on PV-ES economics
- Longer peak duration in hospital results in less NPV/kW compared to large office; however in larger capacity of ES, NPV/kW values are getting closer in two segments





35% difference in NPV/kW

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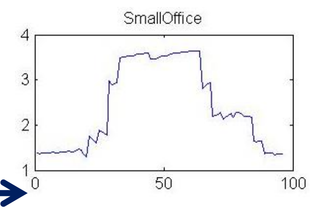
Effect of load shape on PV-ES economics (NPV/kW in 5 yr. horizon)

- Small office V.S. Small hotel:

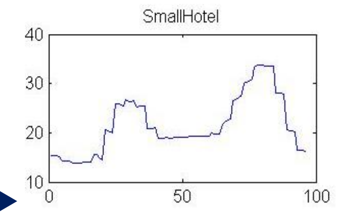
Small office
Annual consumption:
84 mWh

AVG daily load profile

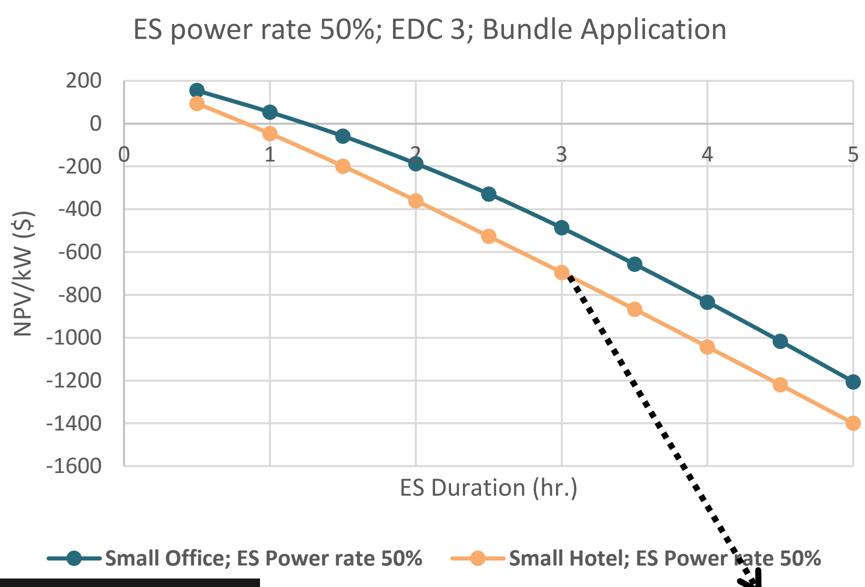


Small hotel
Annual consumption:
757 mwh

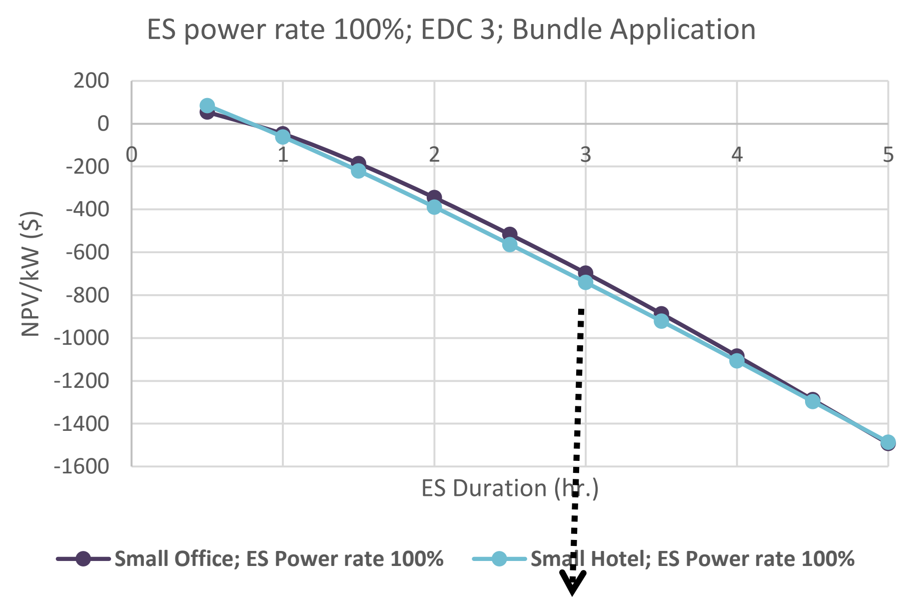
AVG daily load profile



- "After hours" peak in small hotel, causes lower NPV/kW in small systems (effect of load shape)
- High rated capacity enables to shave "after hours" peak and leads to closer NPV/kW values



30% difference in NPV/kW



6% difference in NPV/kW

Effect of EDC cost structure on PV-ES economics

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Effect of EDC cost structure on PV-ES economics

Recalling slide number “9” where overall results (averaged over all segments) were presented

- Impact of EDC rate structure on cash flow values; *peak demand charge* is the *major* player in PV-ES systems *cash flows*

Average growth in annual cash-flow ($) vs. base scenario

EDC 1			EDC 2			EDC 3		
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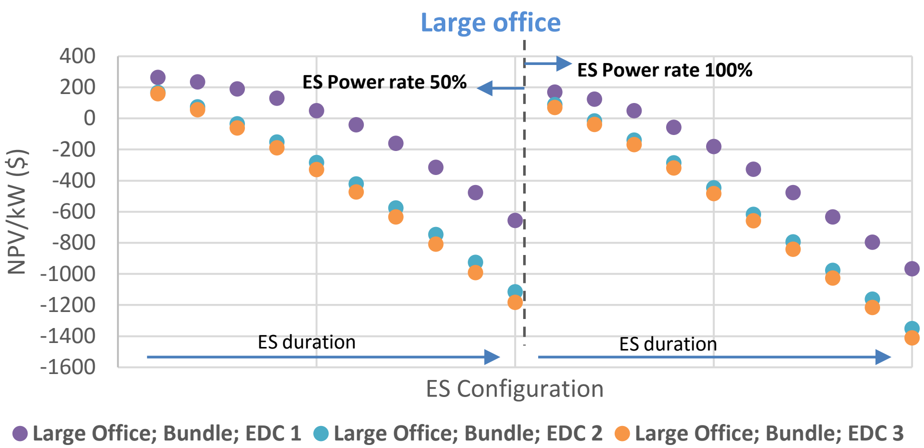
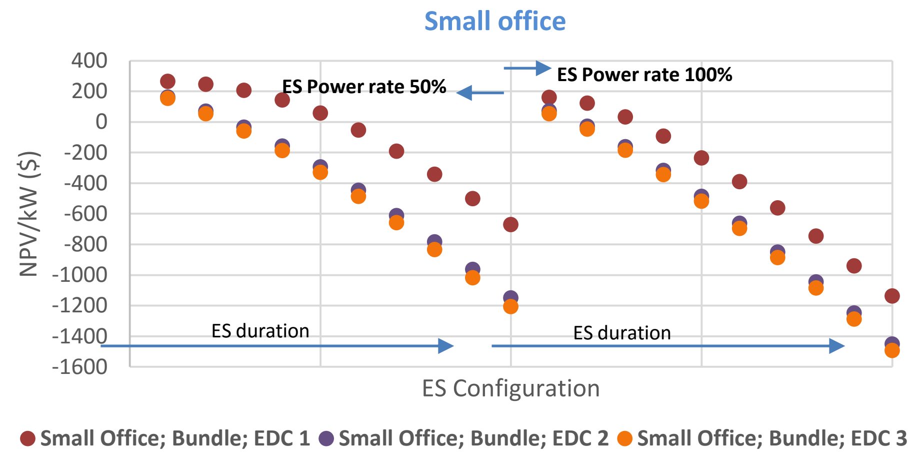
Same order as in kW charges, not kWh

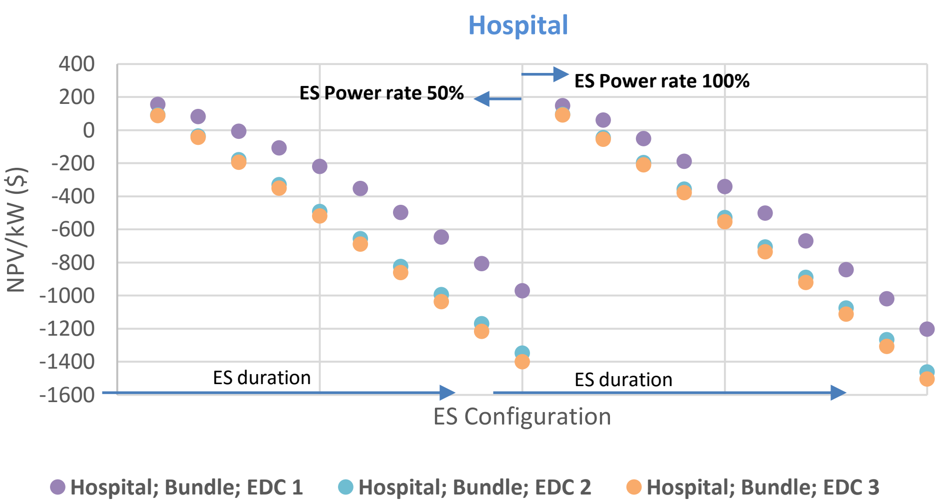
In the next slide we dig deep into all segments

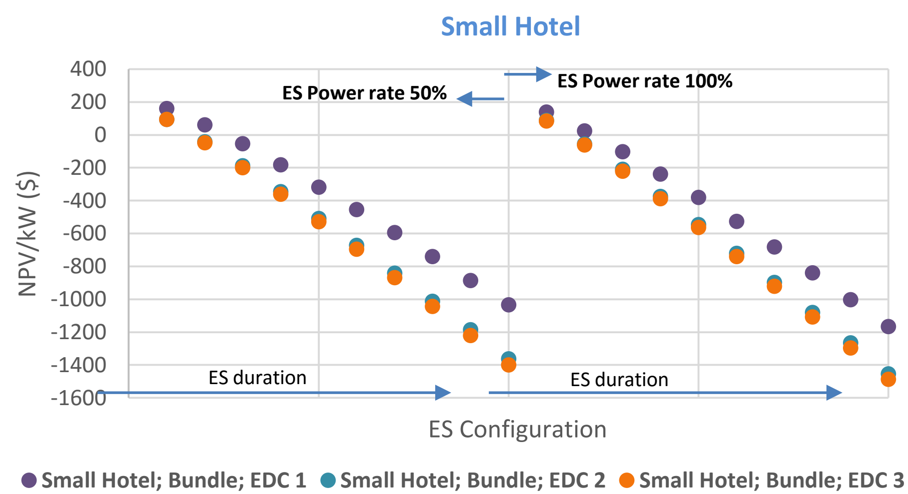
NPV/kW (5yr. horizon) of bundle application for all segments across all EDCs

- Storage system in <u>EDC 1 generates more value (NPV/kW)</u>;
- Demand charge ($/kW) in EDC1 is higher and the <u>major ES value </u>comes from <u>peak demand shaving</u>



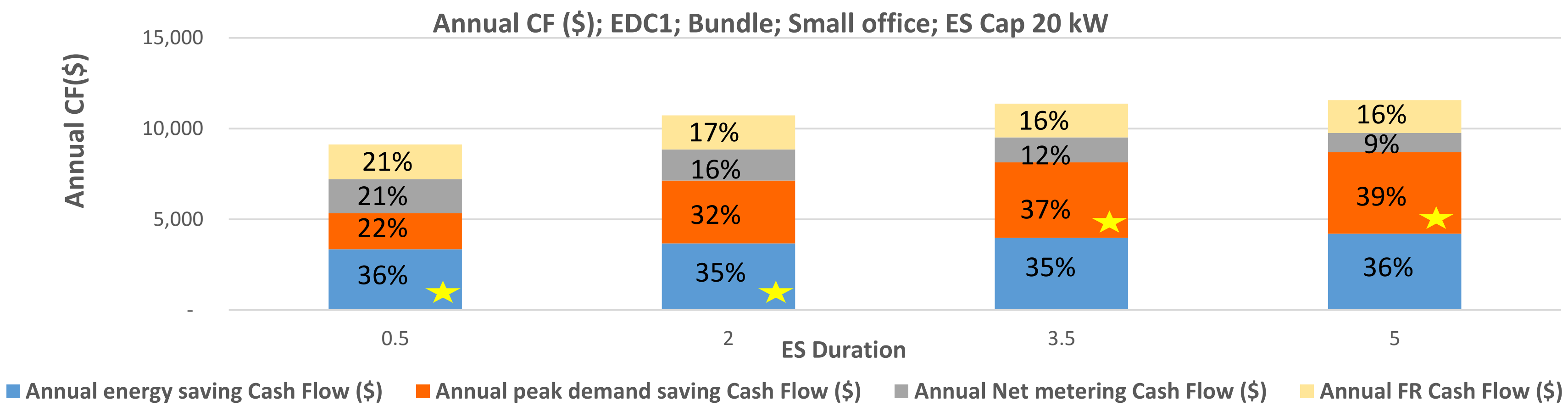


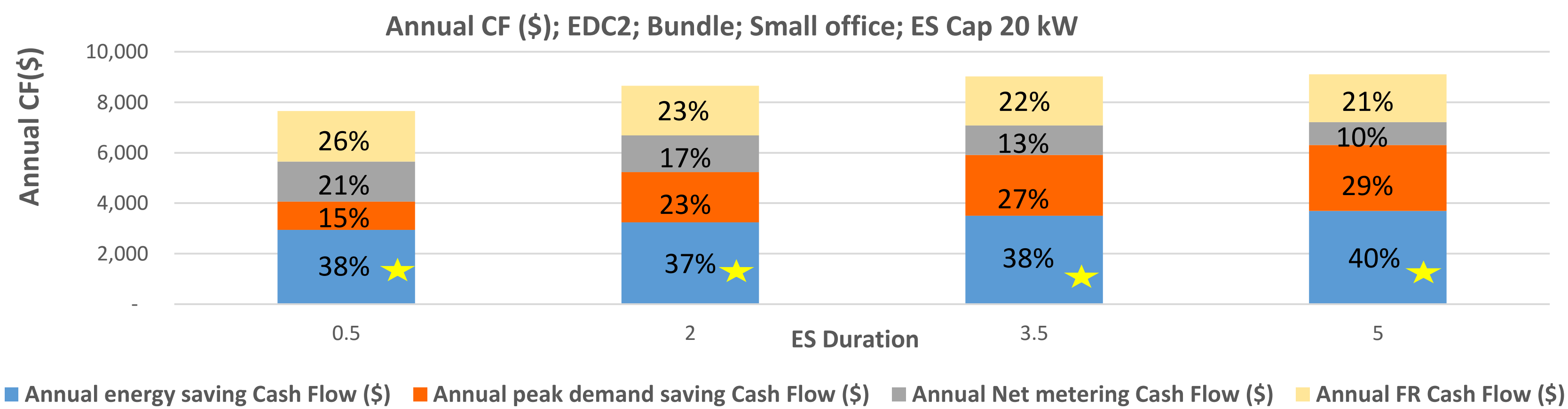




Contribution of revenue streams across EDCs

- Depending on EDC cost structure, contribution of energy saving and peak saving may vary
- Storage system in EDC 1 generates more value because of peak demand saving;





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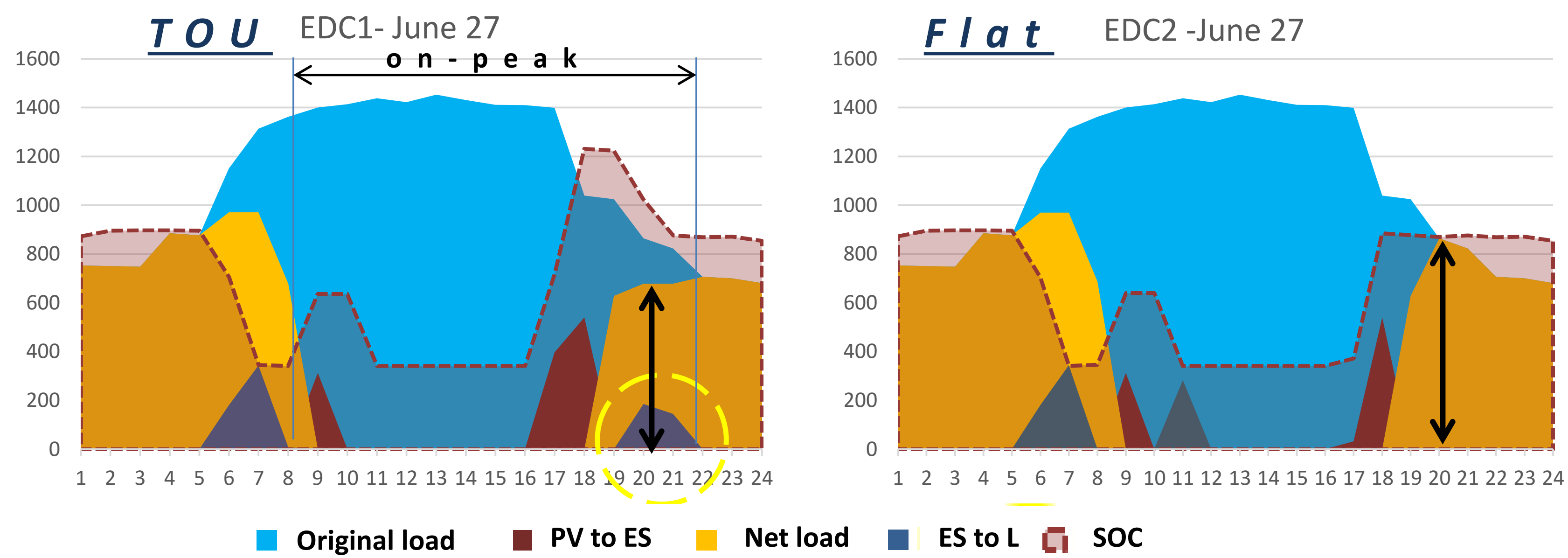
Effect of EDC demand charge structure on daily dispatch; TOU vs. Flat

- ES systems under TOU demand charge tariffs (here EDC1) would generate more revenue through peak shaving

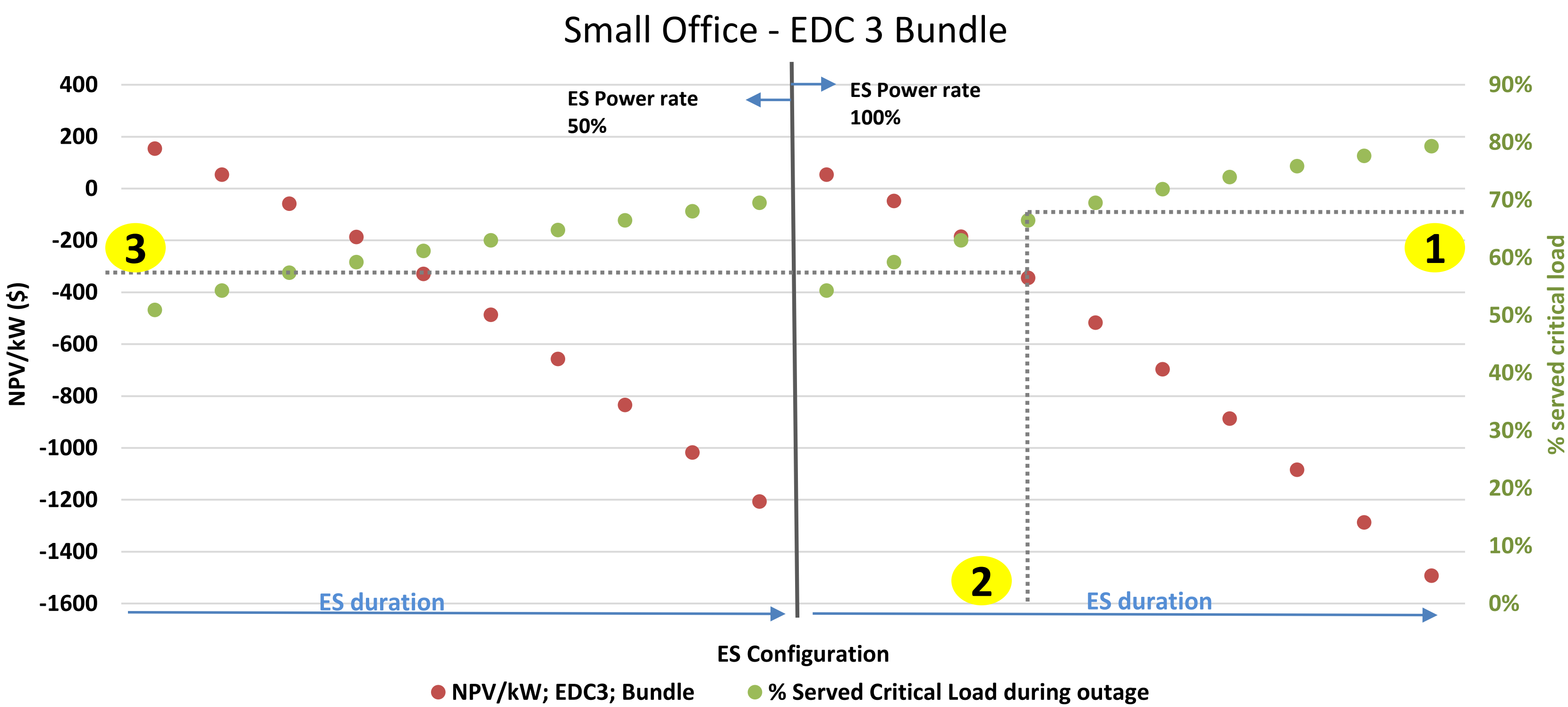


- In both graphs; hour 20: net load in TOU: 678 kW – Flat: 873 kW
- TOU vs. Flat: 12% reduction of net load >> 12% reduction in ramp-up capacity
- TOU helps to smooth out "duck curve"

PV-ES resiliency benefits vs. reduced NPVs (importance of state incentives)

PV-ES systems resiliency benefits vs. reduced NPVs (5yr. horizon); importance of BPU incentives for promoting resiliency

- In order to enhance resiliency and being financially feasible, state incentives are crucial; the bigger the ES systems, the less NPV, the higher resiliency



Owner point of view; non-critical facility

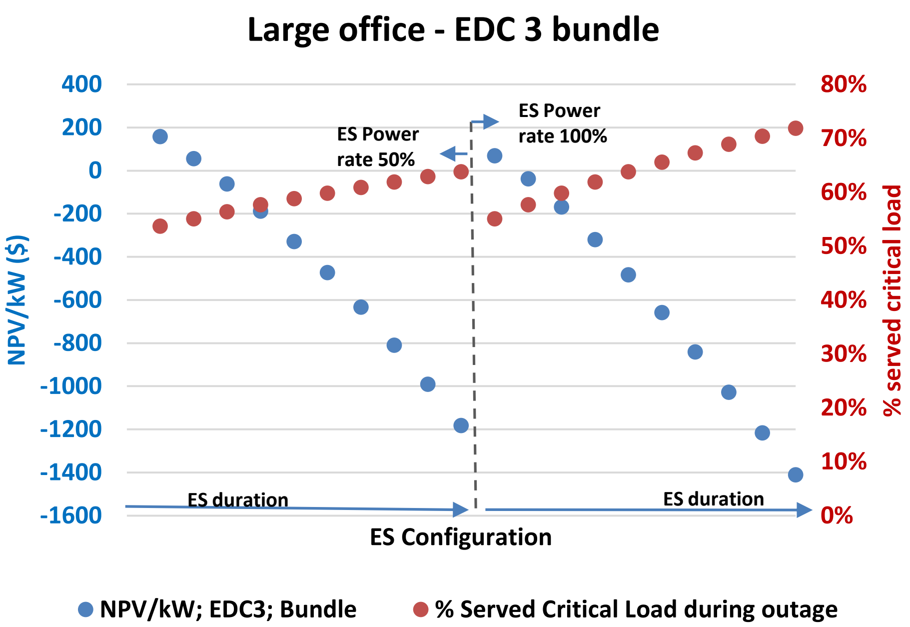
- ✓ Smaller systems
- ✓ Less state incentives needed

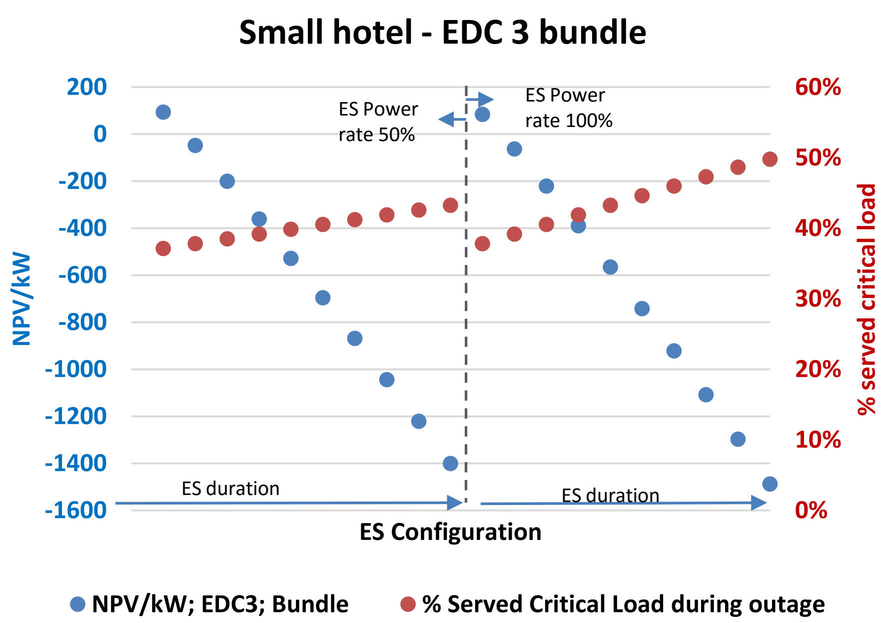
Owner point of view; critical facility (small office as a resemble of police station)

Example: 70% of critical load has to be supplied in blackout events ....

PV-ES systems resiliency benefits vs. reduced NPVs (5yr. horizon); similar behavior in other segments

- Similar behavior in other segments; ESs with <u>longer duration</u> are <u>more resilient</u> but generate <u>less NPVs</u>





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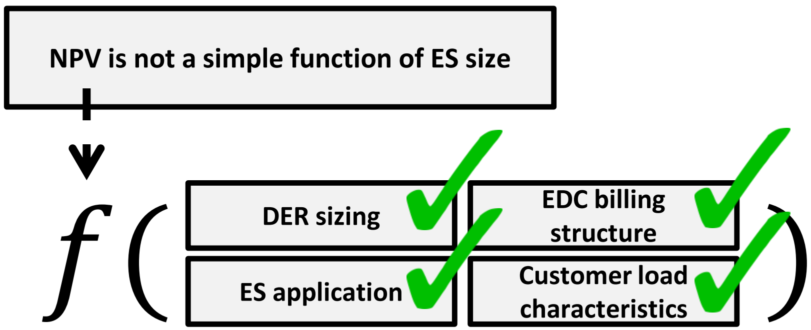
Conclusion of results



- On average *bundle* application provides *the most cash flow* among all applications
- *Peak demand charge* is the *major* player in PV-ES systems *cash flows*
- Increasing the duration of ES results in less NPV/kW because of the higher investment cost
- *Similar electricity load shapes with different load levels* results in *close NPV/kW*
- Load shape may significantly influence on PV-ES economics
- In order to enhance resiliency and being financially feasible, state incentives are crucial

Questions and Discussion

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