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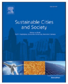

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Towards Nearly Zero-Energy Buildings: Smart Energy Management of Vehicle-to-Building (V2B) Strategy and Renewable Energy Sources

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[Submitted on 3 Oct 2023]

Deterioration modeling of sewer pipes via discrete-time Markov chains: A large-scale case study in the Netherlands

Journal Pre-proof

Capacity degradation analysis and knee point prediction for Lithium-ion batteries

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Abstract_First Paper

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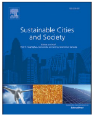

Towards Nearly Zero-Energy Buildings: Smart Energy Management of Vehicle-to-Building (V2B) Strategy and Renewable Energy Sources

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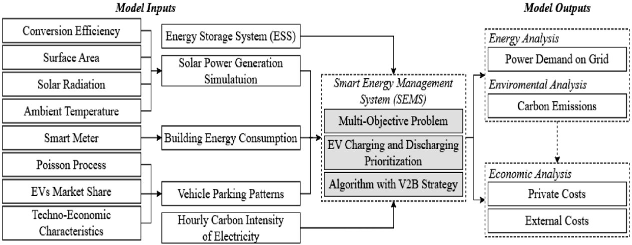
- applying V2B (Vehicle-to-Building) to a building at National Taiwan University
- Rule-based strategy was employed

Motivation

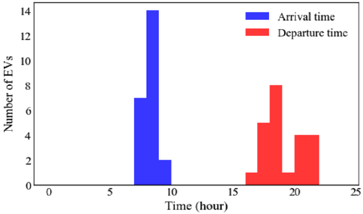
- **V2B is gaining attention for nearly zero-energy buildings (NZEB)** to minimize energy consumption and maximize the use of renewable energy
- With V2B, **EV battery serves as a temporary storage for excess energy** generated by renewable energy or as **a power source during peak demand**
- However, **research on optimal operational strategies for V2B**, or studies considering all relevant variables, **are insufficient**

Smart Energy Management System (SEMS) with V2B



- The SEMS framework comprises four key elements: building, solar PV panels, EVs, and ESS
- operational strategy is established with a one-hour interval

Vehicle Parking Patterns



- target building is the Civil Engineering Building of National Taiwan University, which has a total of 23 parking spaces
- Assumptions about vehicle parking and the use of a Poisson process were applied to derive the distribution of vehicles over time
  - arrive between 7:30 a.m. and 9:30 a.m., depart between 4:30 p.m. and 8:30 p.m.
- initial SoC and required SoC of arriving vehicles are randomly generated between 30% and 90%

Objective function

This study employs a multi-objective optimization

- **(primary objective) minimization of grid power demand**
- (secondary objective) peak shaving

$$\min P_{\text{grid}}(t) = P_{\text{building}}(t) - P_{\text{PV}}(t) + \sum_{i=1}^{N(t)} P_{i,\text{EV}}(t) \times \eta_{\text{EV}} + P_{\text{ESS}}(t) \times \eta_{\text{ESS}}$$

- $P_{\text{building}}(t)$: building's power consumption
- $P_{\text{PV}}(t)$: power generation from PV
- $N(t)$: number of parked EVs
- $P_{i,\text{EV}}(t)$: charge/discharge power of the i-th EV
- $P_{\text{ESS}}(t)$: charge/discharge power of ESS
- η_{EV} and η_{ESS} : power efficiency of EVs and ESS

Objective function

reducing grid load usually aligns with peak shaving, in certain cases where it does not, the primary objective takes precedence

- (primary objective) minimization of grid power demand
- **(secondary objective) peak shaving**

$$\min \Delta P_{\text{grid}} = P_{\text{peak}} - P_{\text{valley}}$$

- P_{peak} : peak power consumption
- P_{valley} : off-peak power consumption

EV Charging/Discharging Prioritization

charging/discharging order of each EV is determined by:

1. calculate the required charging time
2. calculates the priority

1. required charging time

$$T_{\text{charge}} = \frac{(SoC_{\text{req}} - SoC_t) \times C_{EV}}{CDR \times \eta}$$

- SoC_{req} : required SoC when departure
- SoC_t : SoC at time t
- C_{EV} : battery capacity
- CDR : charging/discharging rate
- η : charging/discharging efficiency

EV Charging/Discharging Prioritization

2. Priority values

$$P = \frac{T_{\text{charge}}}{h_{\text{dep}} - t}$$

- T_{charge} : required charging time
- h_{dep} : departure time
- t : current time

Based on priority values, charging/discharging order of EVs is determined:

- positive value : need to be charge
- value of zero : no charging demand and unable to discharge
- negative value : capable of discharging

Rule-based V2B strategy

Input: Building energy consumption, PV power generation, EV parking patterns, state of ESS, charging/discharging rate, charging/discharging efficiency, constraints
Output: Optimal building energy dispatch plan

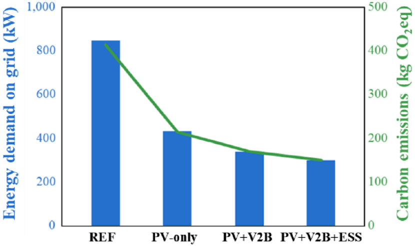
```
for each hour un a day (1 to 24) do
    Update Building energy consumption, PV power generation, EV parking
    patterns, state of ESS
    if power demand on grid in this hour is positive then
        procedure ESS discharging
            repeat
1. ESS              grid demand ← ESS discharging considering efficiency η_ESS
            until no grid demand or ESS reaches minimum capacity limit
        end procedure
        EVs charging and discharging prioritization
        procedure EV discharging
            Sort parked EVs in ascending order based on the priority
            foreach parked EVs do
                Ensure EV has discharging potential based on parking time
2. EV           and charging demand
                repeat
                    grid demand ← EV discharging considering efficiency
                    η_EV
                until discharging rate or no grid demand or EV reaches
                minimum capacity limit
            end foreach
        end procedure
```

- power demand is positive, higher priority to discharging ESS in order to minimize EV degradation
  - (한계점) ESS degradation 을 고려하지 않음

Rule-based V2B strategy

```
else if grid demand in this hour is negative then
    procedure EV charging
        Sort parked EVs in descending order based on the priority
1. EV   foreach parked EVs do
            repeat
                EV charging ← PV power surplus considering
                efficiency η_ESS
            until charging rate or no surplus PV power or EV reaches
            maximum capacity limit
        end foreach
    procedure ESS charging
        repeat
2. ESS      ESS charging ← PV power surplus considering efficiency
            η_ESS
        until no surplus PV power or ESS reaches maximum capacity
        limit
    end procedure
else
    continue
end if
end for
```

- power demand is negative, first charges the EVs and then ESS



	REF	PV-only	PV+V2B	PV+V2B+ESS
Energy demand on gird	847.62 (0%)	431.22 (-49%)	337.81 (-60%)	298.93 (-65%)
Carbon emissions	412.81 (0%)	213.49 (-48%)	169.12 (-59%)	149.39 (-64%)

- V2B showed a 65% reduction in grid demand and carbon emissions, while PV-only scenario showed a 49%
- Despite using hourly control and a simple rule-based strategy, the cost-saving potential of V2B was demonstrated

Abstract_Second Paper


arXiv > stat > arXiv:2310.01888

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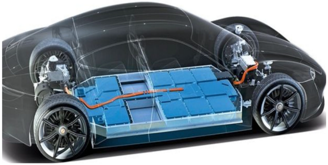
[Submitted on 3 Oct 2023]

Deterioration modeling of sewer pipes via discrete-time Markov chains: A large-scale case study in the Netherlands

L.A. Jimenez-Roa, T. Heskes, T. Tinga, H. Molegraaf, M. Stoelinga

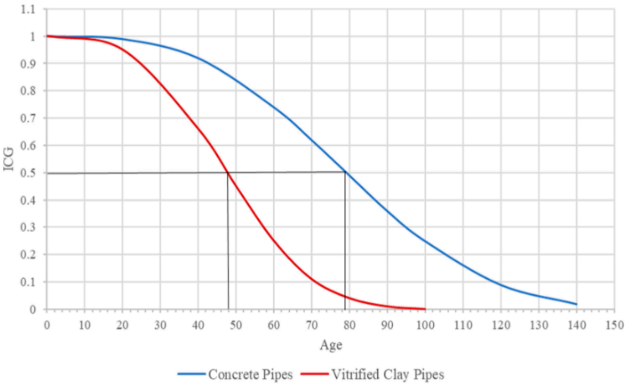
- Modeling sewer pipe deterioration using DTMC with diverse types of sewer pipe data

Sewer pipes vs EV battery



- 하수관 열화의 원인
  - 화학적 요인 (시간) 및 환경적 요인 (온도) 에 의한 열화 (Calender Aging)
  - 운영 요인 (유속과 하중) 에 의한 열화 (Cyclic Aging)

Sewer pipes deterioration curve

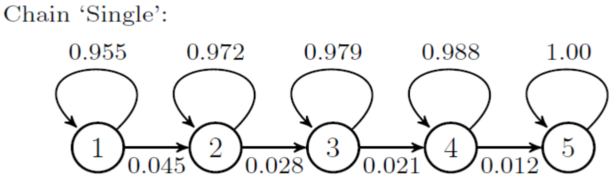


[Fig. 최근 연구들에 의해 도출된 하수관 열화 그래프]

- 시간이 지남에 따라 열화가 급격히 증가하는 경향이 있음 (knee-point)

DTMC

The degree of sewer pipe deterioration is divided into five levels, which serve as the states



To calculate the state probabilities associated with the n-time step $\bar{S}(n)$, apply the Chapman-Kolmogorov equation:

$$\bar{S}(n) = \bar{S}(0)P^{(n)} = \left[S_1^{(n)}, S_2^{(n)}, S_3^{(n)}, S_4^{(n)}, S_5^{(n)}\right]^T$$

- $\bar{S}(0)$: initial state vector
- $P^{(n)}$: transition probability matrix

discretized table

discretized table is generated from the data and used for train DTMC

Count (c)	PipeAge (years)	Time (t)	Step ($\hat{n}$)	$\hat{S}_k^{(\hat{n})}$				
				$k=1$	$k=2$	$k=3$	$k=4$	$k=5$
832	[0,3)	1.5	0	0.95	0.03	0.01	0.01	0.00
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
2'339	[48,51)	49.5	16	0.35	0.50	0.12	0.02	0.01
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
64	[75,78)	76.5	25	0.44	0.20	0.28	0.05	0.03
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮

- $\widehat{n}$: step that discretizes PipeAge
- c: total number of pipes corresponding to a specific PipeAge
- $\widehat{S}_k^{(\widehat{n})}$: probability of each deterioration state (k) at step $(\widehat{n})$

calibration of the DTMC

Err is computed for each step ($\hat{n}$) between the discretized table ($\widehat{S}^{(\hat{n})}$) and the predictions made by DTMC ($\bar{S}^{(\hat{n})}$):

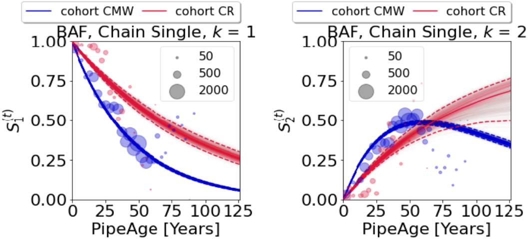
$$\text{Err} = \sqrt{\frac{\sum_{\hat{n},k} \left(\bar{S}_k^{(\hat{n})} - \widehat{S}_k^{(\hat{n})} \right)^2 \times w_{\hat{n}}}{|\hat{n}| \times K}}$$

- $\widehat{S}^{(\hat{n})}$: probability of pipes in each deterioration state
- $\bar{S}^{(\hat{n})}$: predicted probability of pipes in each deterioration state using the DTMC
- $w_{\hat{n}}$: weight for normalize count at each step ($\hat{n}$)

The minimization of Err is carried out through the Sequential Least-Squares Programming (SLSQP) algorithm

Results

results are presented by distinguishing between different pipe types (cohort) and damage types



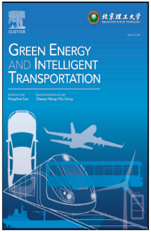
- gray markers represent actual data, bold line indicates the predicted probability of being in the corresponding state based on pipe age
- (한계점) 하수관 퇴화를 예측하는 기존의 다른 방법들 (physics, artificial intelligence) 과의 비교는 제시되지않음

Abstract_Third Paper

Journal Pre-proof

Capacity degradation analysis and knee point prediction for Lithium-ion batteries

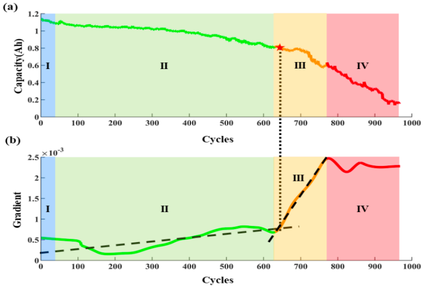
Teng Wang, Yuhao Zhu, Wenyuan Zhao, Yichang Gong, Zhen Zhang, Wei Gao, Yunlong Shang



- knee point is predicted using capacity degradation gradient and the capacity loss with respect to voltage changes
- suggest that the **battery capacity degradation can be divided into four stages**

degradation stages is divided

whole life cycle degradation can be divided into four stages by using gradient



capacity degradation gradient (∇D_i) :

$$\nabla D_i = \frac{Q_i - Q_{i+1}}{N_{i+1} - N_i}$$

- Q : capacity
- N : cycle

- zone I : **gradient constant**
- zones II : **gradient increasing slightly**, loss of lithium
- zone III : **gradient increasing rapidly**, loss of active material, **after knee-point**
- zone IV : **gradient constant**, side reactions

Disccusion

- 마지막 논문에서 제시된 degradation이 4단계로 나뉘어진다는 사실을 바탕으로 두번째 논문과 유사하게 접근하는 것이 가능할지 궁금합니다

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"Thank you for listening"
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