Development of a Regenerative Energy System for Elevator

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ABSTRACT

Lifts in tall buildings run for long hours every day and make up a sizeable part of a building's electricity bill. Whenever a cabin slows down or descends under load, its motion energy is normally burnt off as heat in braking resistors or friction brakes, which wastes power and heats the drive hardware. This paper presents a small laboratory prototype that captures part of that energy instead. A rack-and-pinion lifting arrangement driven by a 12 V DC motor is mechanically coupled to two DC generators; during downward travel the moving cabin turns the generators, which then produce electrical power. A charge controller conditions this output and charges a 12 V, 8 Ah lead-acid battery, from which an inverter can supply light loads such as an LED lamp or emergency lighting. For a sample generator output of 19 V and 2 A (38 W) and a controller efficiency of 80%, the power delivered to the battery is 30.4 W. This figure is a design estimate that will be replaced by values measured on the prototype. The work indicates that low-cost regenerative storage can reduce dependence on the grid and contribute to energy-efficient, sustainable buildings.

Keywords: Regenerative Braking, Elevator, Battery Energy Storage System (BESS), DC Motor, DC Generator, Energy Recovery, Sustainable Building.

I. INTRODUCTION

Elevators have become an integral part of modern infrastructure, especially in multi-storey buildings, commercial complexes, and industries. With the continuous development of smart grid technology, people try to reduce the use of fossil fuels and carbon dioxide emissions. Meanwhile, people are also concerned about energy efficiency, in order to increase the efficient utility of energy. Elevators typically account for a notable share of the overall electricity consumption of a building, and a significant portion of this energy is wasted during braking, where the kinetic energy of the moving car is converted into heat through resistive braking elements.

In this project, a generator motor is coupled with the lift mechanism such that it can generate electricity while the lift is in motion. This regenerated electrical energy is stored in a battery and can be used for auxiliary purposes such as powering emergency lights. Since saving electricity has become an important aspect of sustainability, this project aims to support the development of green buildings and sustainable energy initiatives by recovering energy that would otherwise be wasted.

Gao and Niu [1] analysed the working principles and performance of elevator regenerative energy feedback technology, emphasizing its role in improving overall energy efficiency in modern vertical transportation systems. Their study highlights how regenerative drives convert the kinetic and potential energy generated during braking or downward motion of an elevator into electrical energy, which can be fed back into the power grid or reused within the building system. They examined system configurations such as the double-side PWM converter and the plug-in energy feedback scheme, along with battery- and supercapacitor-based storage methods, and reported that such systems can reduce total energy consumption by 25–40% while minimizing thermal losses in braking resistors [1].

Makar et al. [2] investigated the application of supercapacitor-based energy storage systems in elevator operations to enhance building energy efficiency. Their study focuses on capturing regenerative energy produced during elevator braking and deceleration, which is often wasted as heat in conventional systems. By integrating supercapacitors as temporary energy storage devices, the recovered electrical energy can be reused during elevator acceleration or supplied to other building loads [2].

Further studies reviewed for this project include work on sustainable elevator design using regenerative energy storage in geared and gearless machines [3], an Elevator Energy Regenerative Unit (EERU) for permanent magnet motor elevator systems [4], regenerative braking using supercapacitors [5], intelligent control strategies for regenerative elevator drives with battery energy storage [6], and design/simulation studies of regenerative braking systems for elevators [7], [8], [9]. Reviews on power quality and energy saving using regenerative drives [10] and elevator energy conservation using regenerative drives [11] were also considered.

From the reviewed literature, it is evident that regenerative braking, combined with an appropriate energy storage method (battery or supercapacitor), is an effective approach for reducing elevator energy consumption. However, most reported systems use complex power-electronic converters and are evaluated at full building scale. This project focuses on a simplified, low-cost, DC motor–based prototype using a rack-and-pinion lifting mechanism with dual DC generators, suitable for demonstrating the concept at a laboratory scale before scaling up to real elevator applications.

II. REGENERATIVE BRAKING

In a conventional elevator, the kinetic and potential energy of the moving car is dissipated as heat in mechanical brakes or resistive braking elements during deceleration and downward travel. In regenerative braking, the drive machine is made to operate as a generator while the car descends with a heavy load, or ascends with a load lighter than the counterweight. The mechanical energy of the car is then converted into electrical energy, which is stored in a battery or supercapacitor, or fed back to the supply, instead of being wasted.

In the proposed prototype, two DC generators coupled to the lifting mechanism act as the energy-recovery unit. Their output is passed through a charge controller and stored in a 12 V lead-acid battery for later use.

III. DESCRIPTION OF PROPOSED SYSTEM

Research has been carried out to demonstrate regenerative energy recovery in an elevator system, for which a DC motor was studied and analysed. The motor was chosen after considering various factors, the major ones being cost and efficiency. The methodology adopted for this project involves systematic design, modelling, and analysis integrated with a Battery Energy Storage System (BESS) for elevators. The main objective is to recover the energy generated during elevator motion through regenerative action and store it using a battery system for reuse, thereby improving overall energy efficiency and sustainability.

A pulley-based elevator mechanism was developed using a 12V DC motor. The elevator movement is mechanically coupled with two DC generators. Whenever the elevator moves, the generators convert the mechanical movement into electrical energy. This generated electrical output is measured and then conditioned through the required power-electronic circuit (charge controller and inverter) to operate an LED/bulb load. The generated voltage and current are analysed to evaluate the regenerative energy recovery concept.

3.1 BLOCK DIAGRAM

The block diagram of the proposed system consists of the following stages: AC Supply → AC/DC Converter → DC Motor (12V, 100 RPM) → Pulley System → Elevator Mechanism. The elevator mechanism is coupled to two DC Generators (12V, 100 RPM and 12V, 60 RPM), which produce a DC power output during elevator motion. This output passes through a Charge Controller, which regulates the charging of the battery and prevents overcharging, and then through an Inverter, which converts the stored DC into AC to supply AC loads and an LED bulb.

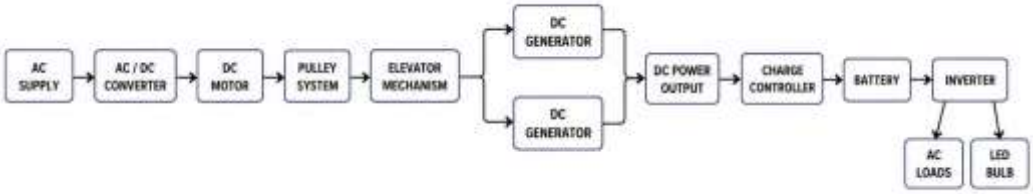


Fig. 1. Block diagram of the proposed regenerative energy system for elevator.

3.2 WORKING PRINCIPLE — RACK AND SPUR GEAR SET

A rack and pinion mechanism is used to convert the rotational motion of the motor into linear motion of the lift. When the motor rotates the pinion, the pinion moves along the fixed rack. Since the motor, generator, and lifting cabin are mounted together, rotation of the pinion causes the entire motor–generator assembly and lift cabin to move upward or downward along the stationary rack. During downward motion, the coupled DC generators are driven mechanically and produce electrical energy, which is fed to the battery through the charge controller.

IV. COMPONENTS USED

Sr. No.	Component	Rating / Specification	Function
1	Square Gear Box Lifting Motor	12V DC, 100 RPM, High Torque	Provides high torque at low speed; used for lifting the elevator cabin.
2	Pulley & Belt System	—	Transfers rotational motion and torque from the motor to the lifting mechanism; economical and reliable.
3	DC Generator Motor (x2)	12V DC (100 RPM & 60 RPM)	Acts as generator to convert mechanical energy (during downward movement) into electrical energy, supplied to the battery via the charge controller.
4	Battery	12V, Lead-Acid	Stores the regenerated electrical energy and supplies backup power to the system.
5	Inverter Circuit	12V DC input, 230V AC output	Converts stored 12V DC into 230V AC to power AC loads such as lighting.
6	Charge Controller	12V/24V DC	Regulates battery charging from the generator output; prevents overcharging and over-discharging.
7	AC/DC Converter (SMPS)	230V AC input, 12V/24V DC output	Converts grid AC supply into regulated DC for charging the battery.
8	LCD Display	16×2, 5V DC	Displays battery voltage, charging current and system status.
9	Telescopic Channel	—	Used as guide rails for the elevator cabin to ensure smooth, stable vertical movement.
10	Rack and Spur Gear Set	—	Converts the rotational motion of the motor into linear motion of the lift cabin.

V. HARDWARE DESCRIPTION

A working prototype has been fabricated using an acrylic-sheet frame, telescopic channel guide rails, a rack-and-pinion lifting arrangement, a 12V DC lifting motor, two coupled DC generators, a charge controller, and a 12V battery, as shown in Fig. 2 and Fig. 3. The prototype demonstrates the mechanical coupling between the lifting motor, the generator set, and the elevator cabin. Fabrication of the mechanical assembly and integration of the electrical components (charge controller, battery, inverter circuit) has been completed; testing and quantitative performance evaluation (voltage, current, and energy recovered per cycle) are in progress.



Fig. 2. Fabricated prototype of the regenerative energy system for elevator.

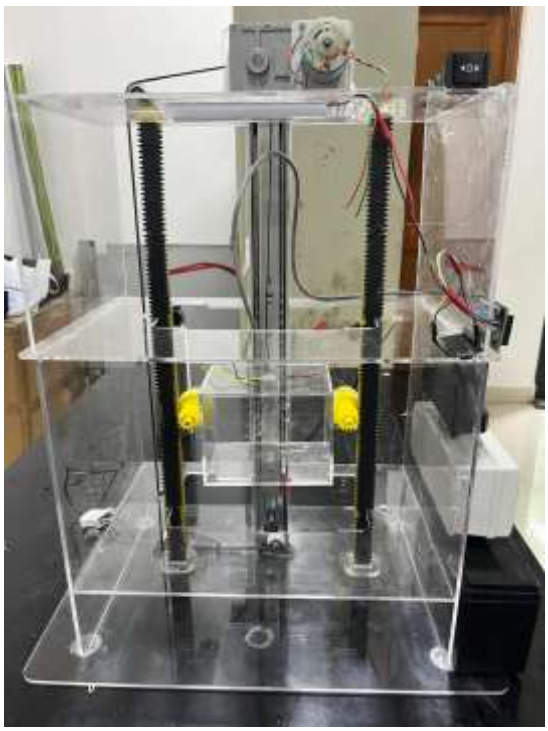


Fig. 3. Front view of the prototype showing the rack-and-pinion lifting mechanism and dual DC generator arrangement.

VI. ENERGY GENERATION, STORAGE AND EFFICIENCY

The energy that would otherwise be wasted during the descent of the cabin is generated by the two coupled DC generators and stored in the 12 V, 8 Ah lead-acid battery through the charge controller. The efficiency of the system is

therefore taken as the ratio of the energy stored in the battery to the energy generated. The symbols used are listed in Table I.

TABLE I. NOMENCLATURE OF SYMBOLS

Symbol	Description	Unit
V_g	Voltage generated by the generating motor	V
I_g	Current generated by the generating motor	A
P_g	Power generated by the generating motor(s)	W
η_c	Efficiency of charge controller and charging system (0.80 as a fraction)	—
P_b	Power delivered to the battery	W
t	Operating time	h
E_{gen}	Energy generated	Wh
E_{bat}	Energy stored in the battery	Wh
η	Efficiency of energy generation and storage	%

6.1 GENERATOR OUTPUT

The electrical power generated by the generating motors is given by:

$$P_g = V_g \times I_g \quad (1)$$

Taking the generated voltage as 19 V and, for example, a generated current of 2 A from the two generating motors:

$$P_g = 19 \times 2 = 38 \text{ W} \quad (2)$$

6.2 ENERGY GENERATED AND STORED

The energy generated over an operating time t (h) is:

$$E_{gen} = P_g \times t \quad (3)$$

The charge controller regulates the generated voltage to the 12 V battery. With an overall controller and charging-system efficiency η_c of about 80%, the power delivered to the battery is:

$$P_b = \eta_c \times P_g = 0.8 \times 38 = 30.4 \text{ W} \quad (4)$$

and the energy stored in the battery over the same time is:

$$E_{bat} = P_b \times t \quad (5)$$

For an operating time of 1 h:

$$E_{gen} = 38 \times 1 = 38 \text{ Wh} ; \quad E_{bat} = 30.4 \times 1 = 30.4 \text{ Wh} \quad (6)$$

6.3 EFFICIENCY

The efficiency of the system is the ratio of the energy stored in the battery to the energy generated, expressed in percentage form:

$$\eta = E_{bat} / E_{gen} \times 100 \% \quad (7)$$

$$\eta = 30.4 / 38 \times 100 = 80 \% \quad (8)$$

The result is a design estimate based on the assumed charge-controller efficiency. The values of E_{gen} and E_{bat} will be replaced by those obtained from the measured voltage and current during the testing of the prototype. The results are summarised in Table II.

TABLE II. SUMMARY OF ENERGY GENERATION AND EFFICIENCY

Parameter	Symbol	Value
Generated voltage and current	V_g, I_g	19 V, 2 A
Generated power	P_g	38 W
Power delivered to battery	P_b	30.4 W
Energy generated (1 h)	E_{gen}	38 Wh
Energy stored (1 h)	E_{bat}	30.4 Wh
Efficiency	η	80 %

6.4 CHARGING CIRCUIT ARRANGEMENT

The arrangement used to charge the battery from the generating motor is shown in Fig. 4. The 19 V DC output of the generating motor must not be connected directly to the 12 V battery. An appropriate 12 V lead-acid battery charge controller (DC-DC charging regulator) is therefore used between the generator and the battery.

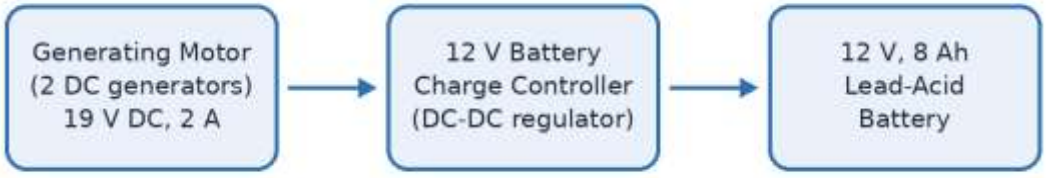


Fig. 4. Circuit arrangement for charging the 12 V, 8 Ah battery from the generating motor.

VII. CONCLUSION AND FUTURE SCOPE

This project demonstrates the feasibility of recovering energy that is otherwise wasted during elevator braking, by using a DC motor–generator arrangement coupled through a rack-and-pinion mechanism, and storing the recovered energy in a battery through a charge controller. For a generator output of 19 V and 2 A (38 W), the power delivered to the 12 V, 8 Ah battery is 30.4 W, so the efficiency of storing the generated energy is estimated at about 80%. The prototype developed so far validates the mechanical design and the energy-generation concept; the remaining work involves quantitative testing of the voltage, current and energy recovered, followed by final result analysis.

As future scope, the system can be extended by: (i) integrating the regenerative unit with a smart-grid interface to feed surplus energy back to the building supply; (ii) exploring higher-density battery chemistries or hybrid battery–supercapacitor storage to improve charge–discharge efficiency; and (iii) scaling the prototype design to a real elevator installation to quantify actual building-level energy savings.

REFERENCES

[1] Peng Gao and Weifei Niu, "Elevator Regenerative Energy Feedback Technology," International Conference on Artificial Intelligence and Engineering Applications (AIEA 2016), Advances in Computer Science Research, vol. 63, pp. 168–175, 2016.

[2] M. Makar, L. Pravica, and M. Kutija, "Super-capacitor-based energy storage in elevators to improve energy efficiency of buildings," Applied Sciences, vol. 12, no. 7184, 2022.

[3] P. Srinivasan and K. Arulvendhan, "Sustainable Elevator Design Using Regenerative Energy Storage in Geared and Gearless Machines," AVE Trends in Intelligent Applied Sciences, 2025.

[4] B. Plangklang et al., "Elevator Energy Regenerative Unit (EERU) for Energy Saving in a Permanent Magnet Motor Elevator System," ICEMS, 2014.

[5] P. Kubade et al., "Regenerative Braking in an Elevator Using Supercapacitor," 2017.

[6] C. Chen, H. Zhang, and X. Liu, "Intelligent Control for Regenerative Elevator Drive Systems with Battery Energy Storage," Energy Conversion and Management, vol. 224, pp. 113–127, Jan. 2020.

[7] S. D. Sawant and A. V. Deshmukh, "Energy Recovery in Elevator System Using Regenerative Braking," International Research Journal of Engineering and Technology (IRJET), vol. 8, no. 6, pp. 2159–2163, June 2021.

[8] H. Patel and S. B. Kumbhar, "Design and Simulation of Regenerative Braking System for Elevators," International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering (IJIREEICE), vol. 9, no. 3, pp. 1–5, Mar. 2021.

[9] M. R. Patel and B. D. Joshi, "Implementation of DC Motor Based Regenerative Braking with Battery Storage," International Journal of Emerging Technologies in Engineering Research (IJETER), vol. 8, no. 10, pp. 59–63, Oct. 2020.

[10] S. A. Khan and P. S. Kulkarni, "Power Quality and Energy Saving in Elevator Systems Using Regenerative Drives," International Journal of Power Electronics and Drive Systems (IJPEDS), vol. 11, no. 3, pp. 1334–1342, Sept. 2020.

[11] B. P. Divakaran, "Elevator Energy Conservation Using Regenerative Drives," Renewable Energy and Sustainable Systems Journal, vol. 6, no. 1, pp. 22–27, 2019.