Retaining the Power Backup of the Battery and Increased Life Span of the Battery for the Solar System- Challenges and Opportunities

P. Sridhar Acharya [1*] & P. S. Aithal[2]

[1]Faculty, College of Computer and Information Science, Srinivas University, Mangaluru, India

Orcid ID: 0000-0002-9996-0014; E-mail: sridharaacharya@gmail.com

[2] Faculty, College of Computer and Information Science, Srinivas University, Mangaluru, India

Orcid ID: 0000-0002-4691-8736; E-mail: psaithal@gmail.com

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P. Sridhar Acharya [1*] & P. S. Aithal[2]
[1]Faculty, College of Computer and Information Science, Srinivas University, Mangaluru, India
Orcid ID: 0000-0002-9996-0014; E-mail: sridharaacharya@gmail.com
[2] Faculty, College of Computer and Information Science, Srinivas University, Mangaluru, India
Orcid ID: 0000-0002-4691-8736; E-mail: psaithal@gmail.com

ABSTRACT

The battery backup plays an important role in storing energy from the solar panel during the daytime. This energy, thus, stored can be utilized for daily usage during day and night. Depending on the amount of power generated from the solar panel the battery bank must be selected. The lifespan of the battery depends on the charging and discharging cycles. The life span also depends on the amount of load connected to the battery as well as the rate at which the current is drained from the battery. It's critical to note the charging and discharging cycles of the battery must be reduced to improve the life span of the same. This paper explains the different types of batteries and the factors affecting the life span of batteries. The paper also suggests the methods to be followed to improve the life span by proposing a model for charging. This model regulates the charging and discharging cycle of a battery to increase the life span of the battery. The model also regulates the charging current by considering the battery temperature. The raise in battery temperature also reduces battery life. The paper performs the ABCD analysis of the new model considering the various issues related to battery performance and socio economic impacts of the same. This paper concludes with the recommendation to implement the charger for the battery-operated devices that do not require fast charging, thus, improving battery life. This paper also concludes with the statement that the proposed model is not suitable for any battery operated devices, which require fast charging where improved battery life is not so essential.

Keywords: Charging cycle, Temperature, Sensor, Lithium ion battery

1. INTRODUCTION :

Energy backup is very essential in all industries, which run on electricity [1]. This is due to the interrupted power supply from commercial suppliers. The industries like the communication sector, OT theatres in the hospitals, research laboratories, ATMs, mobile towers, etc. must get the power supply which should not be interrupted even for a second also [2]. In such conditions depending upon the power requirements, energy backup is very essential to switch over from the commercial energy supply to the diesel energy supply. In some cases where the power requirement is in such a way that the backup power supply using the UPS system could be sufficient. The UPS converts the energy stored in a battery backup to the required load. The new innovation in the automobile industry started using electrical energy stored in a battery backup as an alternative fuel [3].

The energy backup stored in batteries has different capacities of energy storage. The capacity of energy storage in the battery is depending on the output power delivery, and the duration of the power backup. So there are various sizes of energy storage inside the batteries ranging from few watts to a few kilowatts. Even then the energy backup may not be sufficient to fulfil the load. In such cases, the series or parallel combination of batteries serve the purpose of the required output delivery. Various capacities in energy storage decide the size of the battery. Normally all batteries which store the energy are measured in terms of the watt-hour (WH) which means how many watts of the power can be utilized from the battery for how many hours [4]. The capacity of the battery depends upon the number of plates,

size of the plates, the density of the plates, ambient temperature, chemical compositions, etc. [5]. The energy can be stored in the battery backup either from the conventional electrical energy source or from any renewable energy resources [6].
Over the period of battery performance time due to the charging and discharging cycle and other environmental conditions the capacity of the battery decreases [7]. This decay in the battery storage capacity slowly decreases the performance of the same. This factor reduces the life span of the battery. So, implementing such batteries as parallel energy is highly inefficient. The UPS may not perform with the desirable power output with the pre-defined duration. The vehicle may not give the mileage as it was giving in the beginning [8]. So, it's not possible to reach the ideal characteristics of the battery to sustain the life span to be infinity with the same performance as specified in the beginning. It is possible to extend the life of a battery using some techniques in storage and usage of battery energy. To design such a charging and discharging system it's important to understand the factors affecting the life of the battery backup [9].

(1) Ambient Temperature
This is one of the major factors that decide the life span of battery backup. The temperature of the battery backup should be maintained at room temperature (around 25^0 C). The battery starts boiling during the charging time in the case of lead-acid battery and temperature starts increasing during the charging process in the maintenance-free battery as well as Lithium-ion batteries. It is observed that every increase in the temperature by 8.3^0C from the acceptable temperature reduces the life span of the battery by 50%.

(2) Charging and Discharging Cycle
The charging process and discharging process reduce the capacity of all types of batteries like lead-acid, maintenance free and Lithium-ion. The charging process is the amount of energy getting stored in the battery and the discharging process is the amount of energy getting delivered from the battery. Storing the energy from the minimum to the maximum is called a charging cycle. Delivering the energy from the battery to load and thereby bringing the battery energy from maximum to minimum is called the discharging cycle [10]. Every charging and discharging cycle reduce the life span of the battery. Thus, the life of all types of batteries depends on the charging and discharging cycles.

(3) Battery Chemistry
Certain chemical compositions of the Lithium-ion battery find it difficult to sustain the energy stored inside the plates for a long time due to more and more charging and discharging cycle. Over a period of time, the energy storage capacity in the battery reduces.

(4) Application
One of the main reasons which decide the life span of any type of battery is its application. The system which sucks a large amount of energy from the battery of any type at a time during the initial period of the power cut reduces the battery life due to an immediate surge in the stored energy.

2. RESEARCH OBJECTIVES :

The objectives of this paper are:
- Study the performance of lead-acid and lithium-ion batteries with special reference to the extended life span by considering the materials used inside the battery and nature of charging and discharging.
- Factors affecting the life of the battery considering the battery plates, plate density, number of plates and the dielectric medium for the conventional lead-acid battery.
- Propose the model to increase the battery life of all types.

3. METHODOLOGY :

Study the performance of lead-acid and lithium-ion batteries with special reference to the extended life span by considering the materials used inside the battery and nature of charging The performance of lead-acid and lithium-ion batteries depends on the following items:
- The plates which store the energy (both cathode and anode)

- The size of the plates
- The dielectric medium which separates the plates

The plates inside the battery to store the energy play an important role. Depending on the nature of the battery different plates having materials, size and number of plates are decided. The number of such paired plates also counts to the amount of energy stored. In the case of the conventional lead-acid battery, the two plates are lead plate and lead oxide plates with separators. These plates are immersed in sulphuric acid. The sulphuric acid chemically reacts on lead and lead oxide plates to form lead sulphate. This phenomenon is called sulphation. When the battery is getting charged the lead sulphate will be reconverted into lead, lead oxide, and sulphuric acid. If the battery is discharged for a longer duration due to the concept of sulphation, then it loses its ability to restore the charges to form lead, lead oxide, and sulphuric acid. More and more discharge cycle forms the immobile crystals reducing the formation of lead, lead oxide, and sulphuric acid. Thus, the performance of the battery backup reduces with respect to time. The voltage of the battery backup depends on the number of lead plates and the lead oxide plates whereas the current rating (IAH-Ampare Hour) of the battery depends upon the size of the plates. The increased size increases the current rate (AH) of the battery. This increases the size of the battery.
The dielectric medium in lead-acid batteries plays an important role. It should isolate the cathode and anode plates providing infinite resistance to avoid the minor internal leakage current. Due to the material, the acid medium, the dielectric medium fails to provide infinite resistance which causes the internal leakage current. This leakage current prevents the battery from storing the charges for a longer duration. The chemical impurities inside the battery also add up to the limitation of the performance of the battery. Looking into the various limitations of the lead-acid battery and the research work carried out in the Lithium-ion batteries, the lithium-ion batteries proved to be functioning better in terms of power capacity, storage, and duration to withhold the power backup inside. But still, there are limiting factors that decrease the performance of lithium-ion batteries.
Lithium-ion batteries are constructed by having an anode, cathode, the separator which separates the anode with the cathode and the electrolyte material. Here the Lithium is the anode and the carbon plates are the cathode. During the charging the cathode stores the lithium and releases the lithium-ion to the anode internally. Once the lithium-ions are completely moved towards the anode then the battery is considered to be fully charged. During this process, the electrons move externally from the cathode to the anode. During the process of discharging the lithium-ions move from the anode to cathode internally causing the movement of electrons externally. This causes the current flow externally. One complete movement of lithium-ions internally from cathode to anode is called the charging cycle and the reverse cycle is called the discharging cycle. The charging and discharging cycle decide the life of the battery. The mobility of the ions internally reduces due to more charging and discharging cycles. Here raise in the temperature also is a factor for ion mobility. These are going to reduce the life of the battery. The following table 1 shows the factors which influence the life of the battery.

Table 1: Factors affecting the life span of the battery and proposal to improve battery life.

Sl. No.	**Factor Affecting the Life of the battery**	**Under Normal Condition using the conventional chargers**	**Desired Condition (proposal for the new charger)**	**Remark**
1.	Charging cycle	Multiple charging cycles where the charger continues charging till the battery reaches Maximum Voltage.	Charging must start only when the battery voltage reaches Minimum Voltage.	Less Charging cycle improving the battery life
2.	Discharging Cycle	Depends on the load may be fast discharging or slow discharging.	Controlled Discharging	Less discharging cycle improving the battery life

3.	Raise in Temperature	No option. The charger concentrates only on battery Voltage	Maintaining the room temperature	Improved battery life
4.	Load Balancing	Difficult to Achieve as the UPS drains the battery energy depending on the load requirements.	Concentration must be given to the smooth flow of energy from the battery without the maximum current drain for a small period of time	Improved battery life

4. PROPOSED MODEL :

The block diagram of the proposed model is as shown in figure 1.

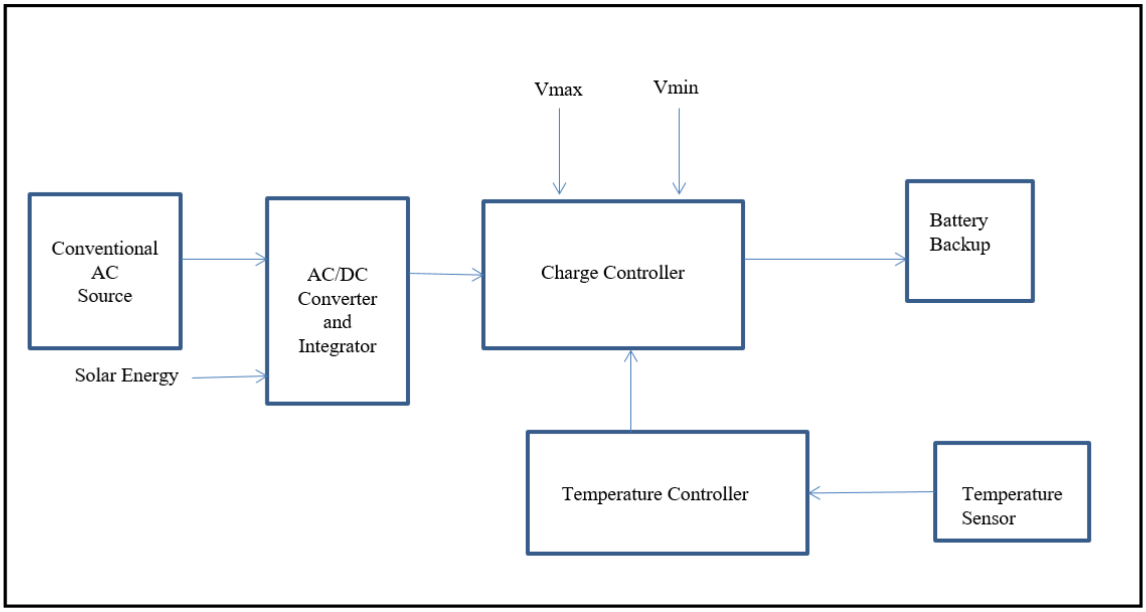

Fig. 1: The charge controller for improved battery life (Proposed model)

5. WORKING OF THE MODEL :

The model concentrates on two important aspects to improve battery life. Here, battery stands for lead-acid, maintenance free battery having gel as the dielectric medium or lithium-ion.

The first objective is to minimize the charging and discharging cycle of the battery. The second objective is to control the flow of current to maintain the temperature of the battery at room temperature. To cope up with the objectives the model has six major functional units namely,

- Conventional AC source/Solar Energy.
- AC to DC converter and integrator.
- Charge controller.
- Temperature controller.
- Temperature sensor.
- Battery Backup.

(1) Conventional AC source/Solar Energy:

This is the energy source which is taken to charge the battery backup. This source can either be a conventional or energy taken from Solar panel. This energy source is given to the AC to DC converter and integrator.

(2) AC to DC converter and integrator:
This unit is used to convert the conventional energy from AC source to the required DC format to be used for charging as well as take the DC energy from the solar panel and integrate with the conventional energy. The output of this unit is the DC energy with Vout and Iout as required by the battery backup.
(3) Charge controller:
This unit is the most important unit which will control the energy flow to the battery backup. The output of this unit is the smooth Vin with Iin which depends on the battery voltage, battery current as well as the battery temperature.
The unit functions with the following conditions

- The unit will start charging only when the battery voltage reaches Vmin
- The unit continues charging until battery voltage reaches Vmax.
- Once Vmax is reached, the unit will cutoff the charging.
- The unit will not charge until the battery voltage reaches Vmin. This charging concept reduces both charging and discharging cycles. The reduced charging and discharging cycle improve the battery life.
- The output current Iout of the charge controller is controlled by the temperature controller which senses the battery temperature using the temperature sensor and then the charging current is controlled by the unit. This reduces the battery overheat. Thus, the battery life is increased.

The unit is designed to increase the battery life. But this unit takes a long time duration to charge the battery.

Table 2: The comparative study of the conventional charger and the proposed charger

Sl. No.	Conventional Charger.	The charger using the proposed model.
1.	Concentrates only on the peak voltage for charging	Concentrates on peak voltage as well as the minimum voltage for charging
2.	The charger works always when the battery voltage is less than Vmax	The charger works only when the battery voltage reaches Vmin
3.	More charging and discharging cycle	Less Charging and discharging cycle.
4.	Charging current depends on the energy stored in the battery	Charging current depends on the energy stored as well as the battery temperature.
5.	More current flow during less energy stored in the battery	The current flow is controlled by the battery temperature.
6.	Less battery life	More battery life

6. ABCD ANALYSIS :

The proposed new model is analysed using a system analysis method called ABCD analysis framework developed by Aithal et al [11- 36]. Table 3 lists the advantages, benefits, constraints, and disadvantages of the proposed new model from user's perspective.

Table 3 : ABCD analysis from stakeholders perspectives

S. No.	Determinant Issue	Key Attributes	Advantages	Benefits	Constraints	Disadvantages
1	Battery Life	Charging cycle.	Less charging cycle.	Less Consumption of energy from the source. Maximum utilization of stored energy.	Slow Battery Performance.	Fast charging is not possible.
		Discharging cycle.	Less discharging cycle.	Less Consumption of energy from the source.	Slow Battery Performance.	Fast charging is not possible.

				Maximum utilization of stored energy.		
		Temperature	Within the range from the normal Temperature to increase the battery life.	Energy storage for a long duration and performance	Slow charging.	Waste of solar energy as energy gets stored in the battery in a slow and study manner.
2	Battery performance	Time factor	Slow and study.	Long duration.	More time for charging.	Difficult in practical situation.
		Cell performance	Very good.	Long duration.	Slow charging and discharging.	Time consuming.
		Durability	Very good	Long Life		
3	Society	Switch over to Battery technology	More and more battery operated applications in the market	Replacement to the fossil fuels More eco-friendly.	Takes a lot of time to accept the battery based applications. Large initial investment. Cost of the battery replacement is huge.	Not suggested for immediate uses where the battery needs to be quickly charged.
		Social benefits	Eco friendly Low maintenance cost	More uses of solar energy in social life	Heavy initial investment. Lack of public awareness. Fear in the society to switch over to the new technology.	Educating the society to switch over to the new technology.

7. CONCLUSION :

The proposed model is concentrating on less charging and discharging cycle as well as the charger looks into the battery temperature during charging. This improves battery life as the major factor for the battery life is the charging and discharging cycle as well as the battery temperature. But this charger is suitable for those applications which take slow charging. Any applications that require fast charging, this model is not suitable.

REFERENCES :

[1] Mekhilef, S., Saidur, R., & Safari, A. (2011). A review on solar energy use in industries. *Renewable and sustainable energy reviews*, *15*(4), 1777-1790.

[2] Scrosati, B., Hassoun, J., & Sun, Y. K. (2011). Lithium-ion batteries. A look into the future. *Energy & Environmental Science*, *4*(9), 3287-3295.

[3] Sabry, A. H., Hasan, W. Z. W., Alkubaisi, Y., & Ab-Kadir, M. Z. A. (2018, November). Battery Backup Power System for Electrical Appliances with Two Options of Primary Power Sources. In *2018 IEEE 5th International Conference on Smart Instrumentation, Measurement and Application (ICSIMA)* (pp. 1-5). IEEE.

[4] Lakshmi, G. S., Olena, R., Divya, G., & Oleksandr, R. (2020, March). Battery Energy Storage Technologies for Sustainable Electric Vehicles and Grid Applications. In *Journal of Physics: Conference Series* (Vol. 1495, No. 1, p. 012014). IOP Publishing.

[5] Xu, W., Read, A., Koech, P. K., Hu, D., Wang, C., Xiao, J., ... & Zhang, J. G. (2012). Factors affecting the battery performance of anthraquinone-based organic cathode materials. *Journal of Materials Chemistry*, *22*(9), 4032-4039.

[6] Dutta, S. (2014). A review on production, storage of hydrogen and its utilization as an energy resource. *Journal of Industrial and Engineering Chemistry*, *20*(4), 1148-1156.

[7] Timmermans, J. M., Nikolian, A., De Hoog, J., Gopalakrishnan, R., Goutam, S., Omar, N., ... & Swierczynski, M. (2016, September). Batteries 2020—Lithium-ion battery first and second life ageing, validated battery models, lifetime modelling and ageing assessment of thermal parameters. In *2016 18th European Conference on Power Electronics and Applications (EPE'16 ECCE Europe)* (pp. 1-23). IEEE.

[8] Lu, R., Yang, A., Xue, Y., Xu, L., & Zhu, C. (2010). Analysis of the key factors affecting the energy efficiency of batteries in electric vehicle. *World Electric Vehicle Journal*, *4*(1), 9-13.

[9] Sweeting, W. J., Hutchinson, A. R., & Savage, S. D. (2011). Factors affecting electric vehicle energy consumption. *International Journal of Sustainable Engineering*, *4*(3), 192-201.

[10] Liu, Y., Zhu, Y., & Cui, Y. (2019). Challenges and opportunities towards fast-charging battery materials. *Nature Energy*, *4*(7), 540-550.

[11] Aithal, P. S., Shailashree, V., & Kumar, P. M. (2015). A new ABCD technique to analyze business models & concepts. *International Journal of Management, IT and Engineering*, *5*(4), 409-423.

[12] Aithal, P. S. (2016). Study on ABCD analysis technique for business models, business strategies, operating concepts & business systems. *International Journal in Management and Social Science*, *4*(1), 95-115.

[13] Aithal, P. S. (2017). ABCD Analysis as Research Methodology in Company Case Studies. *International Journal of Management, Technology, and Social Sciences (IJMTS)*, *2*(2), 40-54.

[14] Shenoy, V., & Aithal, P. S. (2016). ABCD Analysis of On-line Campus Placement Model. *IRA-International Journal of Management & Social Sciences*, *5*(2), 227-244.

[15] Aithal, P. S., Shailashree, V., & Kumar, P. M. (2016). Application of ABCD Analysis Framework on Private University System in India. *International Journal of Management Sciences and Business Research*, *5*(4), 159-170.

[16] Aithal, P. S., & Kumar, P. M. (2016). CCE Approach through ABCD Analysis of 'Theory A' on Organizational Performance. *International Journal of Current Research and Modern Education (IJCRME), 1*(2), 169-185.

[17] Shenoy, V., & Aithal, P. S. (2017). Quantitative ABCD Analysis of IEDRA Model of Placement Determination. *International Journal of Case Studies in Business, IT and Education (IJCSBE)*, *1*(2), 103-113.

[18] Aithal, P. S., Shailashree, V., & Kumar, P. M. (2016). ABCD analysis of Stage Model in Higher Education. *International Journal of Management, IT and Engineering*, *6*(1), 11-24.

[19] Aithal, S., & Aithal, P. S. (2016). ABCD analysis of Dye-doped Polymers for Photonic

Applications. *IRA-International Journal of Applied Sciences*, *4*(3), 358-378.

[20] Aithal, P. S., Shailashree, V., & Kumar, P. M. (2015). Application of ABCD Analysis Model for Black Ocean Strategy. *International Journal of Applied Research*, *1*(10), 331-337.

[21] Raj, K., & Aithal, P. S. (2018). Generating Wealth at the Base of the Pyramid–A Study using ABCD Analysis Technique. *International Journal of Computational Research and Development (IJCRD)*, *3*(1), 68-76.

[22] Aithal, P. S., Shailashree, V. T., & Kumar, P. M. (2016). Analysis of ABC Model of Annual Research Productivity using ABCD Framework. *International Journal of Current Research and Modern Education (IJCRME), 1*(1), 846-858.

[23] Aithal, P. S. (2017). ABCD Analysis of Recently Announced New Research Indices. *International Journal of Management, Technology, and Social Sciences (IJMTS)*, *1*(1), 65-76.

[24] Aithal, A., & Aithal, P. S. (2017). ABCD Analysis of Task Shifting–An optimum Alternative Solution to Professional Healthcare Personnel Shortage. *International Journal of Health Sciences and Pharmacy (IJHSP)*, *1*(2), 36-51.

[25] Aithal, P. S., & Aithal, S. (2018). Factor & Elemental Analysis of Nanotechnology as Green Technology using ABCD Framework. *International Journal of Management, Technology, and Social Sciences (IJMTS)*, *3*(2), 57-72.

[26] Aithal, P. S., Shailashree, V., & Kumar, P. M. (2016). The study of new national institutional ranking system using ABCD framework. *International Journal of Current Research and Modern Education (IJCRME)*, *1*(1), 389-402.

[27] Aithal, P. S., Shailashree, V., & Kumar, P. M. (2016). Factors & Elemental Analysis of Six Thinking Hats Technique Using ABCD Framework. *International Journal of Advanced Trends in Engineering and Technology (IJATET)*, *1*(1), 85-95.

[28] Aithal, P. S., Shailashree, V., & Kumar, P. M. (2016). Analysis of NAAC Accreditation System using ABCD framework. *International Journal of Management, IT and Engineering*, *6*(1), 30-44.

[29] Aithal, P. S., & Aithal, S. (2017). Factor Analysis based on ABCD Framework on Recently Announced New Research Indices. *International Journal of Management, Technology, and Social Sciences (IJMTS)*, *1*(1), 82-94.

[30] Moridi A, Yarahmadi R, Abedi Z. (2020). Prioritizing new air pollution (gases and vapours) technologies based on CBA (Cost-Benefit Analysis) method. Iran Occupational Health, 17(6), 1-2. http://ioh.iums.ac.ir/article-1-2435-en.pdf

[31] Aithal, P. S. (2019). Information Communication & Computation Technology (ICCT) as a Strategic Tool for Industry Sectors. *International Journal of Applied Engineering and Management Letters (IJAEML)*, *3*(2), 65-80.

[32] Aithal, P. S., & Aithal, S. (2019). Management of ICCT underlying Technologies used for Digital Service Innovation. *International Journal of Management, Technology, and Social Sciences (IJMTS)*, *4*(2), 110-136.

[33] Aithal, P. S., & Aithal, S. (2019, October). Digital Service Innovation Using ICCT Underlying Technologies. In *Proceedings of International Conference on Emerging Trends in Management, IT and Education* (Vol. 1, No. 1, pp. 33-63).

[34] Aithal, P. S. (2018, December). Emerging Trends in ICCT as Universal Technology for Survival, Sustainability, Differentiation, Monopoly and Development. In *Proceedings of National Conference on Advances in Information Technology, Management, Social Sciences and Education,* (pp. 130-141).

[35] Aithal, P. S., & Madhushree, L. M. (2019). Emerging Trends in ICCT as Universal Technology for Strategic Development of Industry Sectors. Chapter in a Book-IT and Computing for all the Domains and Professionals: The Emergence of Computer and Information Sciences, Edited by P.

K. Paul, A. Bhuimali, K. S. Tiwary, and P. S. Aithal published by New Delhi Publishers, New Delhi. *New Delhi*, 1-26.

[36] Madhushree, L. M., Radhakrishnan, R., & Aithal, P. S. (2019). A Review on Impact of Information Communication & Computation Technology (ICCT) on Selected Primary, Secondary, and Tertiary Industrial Sectors. *Saudi Journal of Business and Management Studies*, *4*(1), 106-127.

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