

Energy Policy and Opportunities for Biomedical Engineering, Economic Model for Clinical Wastes

¹Ogbonna Nnamuchi, ²Amaka Nnamuchi

¹Chukwuemeka Odumegwu Ojukwu University, P.M.B 02 Uli Anambra State

²Chukwuemeka Odumegwu Ojukwu University, P.M.B 02 Uli Anambra State

DOI: <https://doi.org/10.5281/zenodo.19940950>

Published Date: 30-April-2026

Abstract: Energy related issues have been actively present in economic literature since the 1973 oil crisis. As early as 1865, W.S Jevons expressed his concern about the eventual depletion of coal resources in his book “*The Coal Question*”^[4]. One of the best - known early attempts to work on the economics of exhaustible resources was made by H. Hotelling who derived a price path for non-renewable resources, known as *Hotelling’s rule*^[5]. As Engineering Materials are energy driven, their configurations are not hazardous but rather driven and determined by precise laws of *minimization of energy*. This is not only true for homogenous elastic materials, but also for new composite materials, in the context of elasticity, viscoelasticity, thermos - elasticity etc. Hence the need to carry out extensive research on the nature, how, and why minimizers are reached and how they explain important phenomena such as cavitation, fracture, fatigue and damage that might provoke cost effectiveness of energy. The foregoing constitutes just one aspect of this study.

Keywords: Energy Policy, Biomedical Engineering, Engineering Materials, energy driven.

1. BACKGROUND AND RATIONALE

1.1 Energy policy and regulations issues Definition 1.0.1:

Energy policy is the way a given entity, governmental body usually had decided to address issues of energy development including energy conservation (Electricity → Chemical etc). A lot of these go on in the healthcare system, distribution and use of medical products. As Legislation/regulations are attributes of energy policy including international treaties, and incentives to investment, one can use the Social Sciences tool vs Engineering/ Mathematical Analysis tools to gain insights into energy consumer behaviour to empower policy makers (by way of Energy-Healthcare Informatics – which might build upon pre-existing or become a new research direction), to make better decisions about broad-based climate and energy options, as access to energy is prominently dominant factor for basic social needs such as lighting, heating, cooking, and health care.

2. SIGNIFICANCE OF RESEARCH/RESEARCH RATIONALE

(i) Energy policy and energy efficiency opportunities in Biomedical Engineering (BME)

The Modern hospital is a great industrial achievement^[1]. Medical technologies found in hospitals have greatly extended both the quantity and quality of consumers’ lives. Advancements in these technologies have allowed medical professionals to deliver products such as replacements of worn-out joints, bone implants and bone marrow transplant while same requires maintaining breathing and circulation while a patient’s organs lay bare during surgery, or to use controlled nuclear radiation to diagnose and treat diseases such as cancer (Radiotherapy). Patients, and Doctors rely on these technologies, which in turn depends on availability of large supply of diverse reliable energy sources to function. Biomedical Engineers as designers

are required to meet the needs of the users of these equipment and facilities they create. This is to ensure the Health and safety of patients and Medical staff; as well as to ensure conditions for diagnostic work. This way, energy efficiency can be ensured so that energy saving measures do not compromise medical outcomes.

There are a wide variety of activities, involving product and services that consume energy within the scope of Biomedical Engineering, from producer, research and development, material selection and manufacturing of product, operation and maintenance of equipment, even to use and end-of-life recycling, re-use, and disposal.

Therefore, energy efficiency and policy present huge and diverse opportunities for Biomedical Engineers, and clinicians in research and in practice. Important to note is that post disaster response and development aid can be achieved when we focus on energy efficiency in medical facilities including laboratories where energy supplies to run equipment may be limited and unreliable.

In Australia for instance, this is particularly, topical given the issues around diagnostic integrity and longer-term maintenance of more than \$1 billion worth of generally ageing medical technology equipment in the nation's hospitals.

A range of new opportunities for Biomedical Engineering/Clinical Engineering in energy related areas abound and are as follows:

- (i) An Understanding of life cycle of components for Clinical Devices
- (ii) Systems thinking applied to delivery of services so that upstream and downstream energy waste can be avoided, e.g Virtual systems to deliver services via the internet e.g Telemedicine while entrenching best medical practices. Telemedicine services involves the integration of Health Technology with IT to reduce the need for patients to travel to see a doctor, especially in the care of routine physical check-ups that can be done remotely, thus reducing the use of fuel (cost) for transport.
- (iii) Familiarity with the energy performance of new testing, diagnosis, and implant equipment (to help inform procurement choices).

Engineering has been specifically identified as a profession with opportunities to make substantial contributions to a clean and energy efficient future. To further enable skills development in this field, there's a need for the biomedical industry and universities to collaborate in developing innovative and digitally targeted resources on energy efficiency assessment. This of a necessity provides for Health care informatics or medical informatics that today span all areas of Social Science, Science, Biology, Engineering, Technology,

Medicine and health sector, Public Health, Biology, Microbiology etc enabling both medical and non-medical professionals who either work or are transiting into clinical, quality and/or patient safety roles, as change is constant in today's health care environment.

Despite these new innovations and technologies, the challenges of strained health care resources, high turnover and long wait times continue to impact the patient experience. For best (Economical in all sense) clinical patient care and practices in Health care, safety, Quality informatics and Leadership (SQIL) are essential ingredients, and should be studied from the economical perspectives while upholding the diverse and broad policies that govern them. Numerous opportunities exist to reduce wasted energy and improve energy efficiency in medical facilities by redesigning and optimising equipment, HVAC (Heating Ventilation and Air Conditioning) systems, and lighting, sterilization, equipment, and laundry facilities.

Thus, viewing clinical research in the perspectives of Health informatics or biomedical informatics, the intersection of people, technology and data to improve the safety and quality of patient care can be found in many forms: patient portals, Electronic Medical Records (EMR's), telehealth, healthcare apps, and a variety of data reporting tools. It is a term that describes the acquisition, storage and retrieval and use of healthcare information to foster better collaboration among a patient's various healthcare providers. This plays a critical role in the push towards healthcare reform (involving Healthcare Policy from the Energy Perspective).

Comprehensive research is required to delve into the activities of bodies such as the MHRA (Medicines and Healthcare products Regulatory Agency) which is recognised globally as an authority in regulating medicine, medical devices and blood components for transfusion in the United Kingdom.

(ii) Study of the transfer from a Linear to a Circular Economy using Biomedical Material

To maintain circular economies, obsolete products must be recovered and restored to economic value by addressing all the factors that make it undesirable [2]. Healthcare activities protect and restore health and save lives. But what about the waste and by-products they generate? The common belief is that engineers will face a lot of complexity transferring the healthcare industry into a circular economy because the waste is often discarded for safety reasons. A kind of hygienic obsolescence.

Nevertheless, the World Health Organization (WHO) estimates that 85% of the waste issued from Healthcare activities are non-hazardous [3]. So it is imperative to explore the possibility of building a suitable Mathematical/Engineering Model of any appropriate recovery strategy to harness the lots of transformational potential within the medical industry. This is in tandem with the mechanisms by which products become waste and can be interpreted as a loss of perceived value. This loss is caused by several factors viz:

1. Physical obsolescence: the product breaks down beyond economic repair
2. Functional obsolescence: the product is no longer needed
3. Technical obsolescence: the product is outperformed by newer technology
4. Economic obsolescence: the product is no longer profitable
5. Legal obsolescence: the product is made illegal due to regulation changes
6. Desirability obsolescence: the product is no longer aesthetically appealing

Engineers could find it tricky to redesign medical devices to be sustainable since any reduction in functionality, or increased risk, could endanger a patient's life. Additionally, logistical questions surrounding waste retrieval and acceptance barriers arises.

Nonetheless, if a catheter could be sterilized to regulatory standards, while maintaining functionality, then theoretically it could be used indefinitely. So, it suffices to select biomedical materials that can be easily reused, sterilized and recycled.

It is crucial that any researcher working in these directions should gain adequate coaching to do the following as part of their projects, making reference to the tools in links below.

- i. How to select sustainable biomedical materials - using CES EduPack and the Eco-Audit Tool - or how to introduce these concepts into this project, contact with the organisers of this webinar and similar webinars would be of good resource: Biomedical materials and the Circular Economy.
- ii. Simulation, Modelling & Analysis Solutions for Energy

The increasing worldwide need for reliable energy at a reasonable cost, combined with growing environmental concerns, has brought energy science and engineering into the global spotlight. Companies (including the MED Industry) are challenged to improve existing power generation technologies, improve energy intensity, reduce energy use, and develop innovative new solutions that balance demand, cost and environmental priorities.

Applying engineering simulation early in product and project development enables cost effective ways to evaluate new concepts, faster and with greater frequency than with traditional prototyping and testing methods.

Energy based projects benefit from the high-fidelity, full functionality and multidisciplinary capabilities of engineering simulation software. ANSYS has an established leadership position in energy and related industries. Its solutions are being employed in energy production and power generation projects - including renewable (wind, solar, fuel cells, hydropower, ocean & tidal waves, nuclear, fossil fuels (coal, oil and gas), as well as energy reduction and efficiency projects. ANSYS engineering simulation for energy expand across product and process design, pollution reduction and control, carbon reduction and separation, improved fuel efficiency, and reduced packaging weight, new fuel development, and meeting energy efficiency and regulatory requirements. This would define a task for the Energy Economists, and the Clinical Engineers.

It is my thought that when projects are properly defined, getting in touch with industry partners in the specific are concerned is usually very helpful.

3. RESEARCH TIMELINE

Research should be carried out in consideration of the perceived need for the outcome of that research to be useful to the Government, funders, and other countries, the global Medical Industry, NHS in particular, and the perceived overwhelming support that is to be sought in support of the project. It is proposed that a reasonable timeline of period required to accomplish the project and submit report to the authority be stipulated from the beginning.

4. PROPOSED INDUSTRIAL PARTNERS THAT MAY BE SOUGHT AFTER FOR RESOURCES INVOLVING CLINICAL RESEARCH PROJECTS BOTH IN THE UK OR ELSEWHERE

- (i) Industry Partners, and/or Medical Industry partners of the School of Social Sciences/the Lead Scientists (Project Supervisors).
- (ii) Possible Engagement of ANSYS for Simulation, Modelling and analysis solutions for energy.
- (iii) NHS, and Dundee Institute of Medical Science and Technology (IMSAT) for any technological and other requirements that may be appropriate. This can be replicated anywhere.
- (iv) World Health Organisation (WHO)
- (v) Health Informatics Center (HIC), School of Medicine, Ninewells Hospital and Medical School, Dundee, Scotland. For relevant records, and/or data/technology.
- (vi) MHRA, UK for consultation and patency of any possible discoveries/Intellectual Property.

5. ENDING NOTE

Thank you for taking the time to read through this paper. I regret any inconvenience that might have been created by the diversity of thoughts. I would be happy to have future papers guided by points from this article or by entirely any other research definition that collaborators, and/or researchers might be willing to provide.

REFERENCES

- [1] Ferreira da Cunha, R., & Missemer, A. (2020). The Hotelling rule in non-renewable resource economics: A reassessment. *Canadian Journal of Economics/Revue Canadienne D'économique*. <https://doi.org/10.1111/caje.12444>
- [2] Jaakkola, M. S., & Jaakkola, J. J. K. (2006). Biomass Fuels and Health. *American Journal of Respiratory and Critical Care Medicine*, 174(8), 851–852. <https://doi.org/10.1164/rccm.2604004>
- [3] Missemer, A. (2012). William Stanley Jevons' The Coal Question (1865), beyond the rebound effect. *Ecological Economics*, 82, 97–103. <https://doi.org/10.1016/j.ecolecon.2012.07.010>
- [4] Parnell, H. (2019, October 9). *Using Biomedical Materials within a Circular Economy Ansys*. Ansys.com; Ansys Inc. <https://www.ansys.com/blog/biomedical-materials-circular-economy>
- [5] World Health Organization. (2024, October 24). *Health-care Waste*. WHO; World Health Organization: WHO. <https://www.who.int/news-room/fact-sheets/detail/health-care-waste>