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Center of Excellence for Water

The WEF Nexus Summer School 2023

Prof. Mahamed M. Awad

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*Exchange, Training, and Scholarships Pillar activities are
implemented in cooperation with:*





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Brief introduction about myself

- In 2022, I attended The Water-Food-Energy Nexus Winter School, organized by Center of Excellence for Water (CoE), The American University in Cairo, 16 January-31 March 2022.
- With the people at this Winter School, I have many publications such as:



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Brief introduction about myself

- M.A. Abdelzaher, and Mohamed M. Awad, 2022, “Sustainable Development Goals for the Circular Economy and the Water-Food Nexus: Full Implementation of New Drip Irrigation Technologies in Upper Egypt”, Sustainability, Volume 14, Issue 21, Manuscript ID: sustainability-1767060: 13883.
- <https://doi.org/10.3390/su142113883>
- <https://www.mdpi.com/2071-1050/14/21/13883/htm>
- <https://www.mdpi.com/2071-1050/14/21/13883/pdf>
- https://www.mdpi.com/journal/sustainability/special_issues/Sustainable_Water_Management
- تكنولوجيات جديدة - عالمان مصريان يقدمان مشروعاً بحثياً عن تقنيات جديدة للري الذكي
- <https://www.youtube.com/watch?v=LD4DMxBbsxg>



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Brief introduction about myself

- M. A. Abdelzaher, Eman M. Farahat, Hamdy M. Abdel-Ghafar, Basma A. A. Balboul, Mohamed M. Awad, 2023, “Environmental Policy to Develop a Conceptual Design for the Water–Energy–Food Nexus: A Case Study in Wadi-Dara on the Red Sea Coast, Egypt”, Water, Volume 15, Issue 4, Manuscript ID: water-2168580, 780, The special issue “Renewable Energy Systems Flexibility for Water Desalination”.
- <https://doi.org/10.3390/w15040780>
- <https://www.mdpi.com/2073-4441/15/4/780>
- <https://www.mdpi.com/2073-4441/15/4/780/pdf?version=1676544044>
- https://www.mdpi.com/journal/water/special_issues/systems_flexibility



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Brief introduction about myself

- Ahmed A. Hassan, and Mohamed M. Awad, 2023, “Bibliometric Analysis on Hybrid Renewable Energy-Driven Desalination Technologies,” Energy Nexus, Volume 11, 100215.
- <https://doi.org/10.1016/j.nexus.2023.100215>
- <https://www.sciencedirect.com/science/article/pii/S2772427123000451>



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Brief introduction about myself

- Ahmed A. Hassan, Mohammed Ezzeddine, Mohamed G. M. Kordy, and Mohamed M. Awad, 2023, “Techno-Economic Assessment of Atmospheric Water Harvesting (AWH) Technologies,” Chapter 8 in Atmospheric Water Harvesting Development and Challenges, Elvis Fosso-Kankeu, Ali Al Alili, Hemant Mittal and Bheki Bheki (Eds.), Springer.
https://link.springer.com/chapter/10.1007/978-3-031-21746-3_8
- <https://link.springer.com/book/10.1007/978-3-031-21746-3>



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Brief introduction about myself

- Sanju John Thomas, Mukund Haribhau Bade, Sudhansu Sekhar Sahoo, Sheffy Thomas, Ajith Kumar, Mohamed M. Awad, 2022, “Urban Water Management with a Full Cost Recovery Policy: The Impact of Externalities on Pricing”, Sustainability, Volume 14, Issue 21, Manuscript ID: sustainability-1790465: 14495, **The Special Issue “Towards COP27: The Water-Food-Energy Nexus in a Changing Climate in the Middle East and North Africa”**.
- <https://doi.org/10.3390/su142114495>
- <https://www.mdpi.com/2071-1050/14/21/14495/htm>
- <https://www.mdpi.com/2071-1050/14/21/14495/pdf>
- https://www.mdpi.com/journal/sustainability/special_issues/COP27_WaterFoodEnergy



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Topic Importance: Water, Energy and Food Nexus

- MIT receives \$30 million to help address energy challenges in Egypt
- <http://news.mit.edu/2019/usaaid-grant-30-million-energy-challenges-egypt-0327>
- 3 Centers of Excellence funded by USAID through a total investment of \$90 million
- The Center of Excellence in Energy
- The Center of Excellence in Water
- The Center of Excellence in Agriculture
- The Center of Excellence in Energy has 3 Egyptian Universities
- Ain Shams University
- Mansoura University
- Aswan University



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Topic Importance: Water, Energy and Food Nexus

- Energy Nexus Editorial Board
- <https://www.journals.elsevier.com/energy-nexus/editorial-board>
- Editorial board by country/region
- 71 editors and editorial board members in 29 countries/regions
- China (13), India (8), Canada (5), Greece (5), United States of America (5), Australia (4), Italy (4), Germany (2), Pakistan (2), South Africa (2), Turkey (2), United Kingdom (2), Austria, Brazil, Cyprus, Denmark, Egypt, Hong Kong, Iran, Mexico, Norway, Palestine, State of, Poland, Qatar, Saudi Arabia, Singapore, South Korea, Spain, Sweden



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Topic Importance: Water, Energy and Food Nexus

- This journal welcomes contributions that support and advance the UN's sustainable development goals, in particular **SDG 7** (Affordable and clean energy) and **SDG 11** (Sustainable cities and communities)
- Free* (standard fee: \$1850)
- Article Publishing Charge for open access
- *This discount is valid for all authors who wish to publish open access and submit their article by 31 December 2023



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Topic Importance: Water, Energy and Food Nexus

- **Energy:**
- Water use in bioenergy, power plants, Hydropower, shale gas extraction
- NET ZERO or negative emissions energy systems
- **Energy and Thermodynamic analysis**
- Carbon and Water Footprint
- Hydrogen energy
- Water use in carbon capture and storage
- **Materials utilization and recycling in the Energy industry**
- Energy efficiency and the circular economy
- Energy cost in water use and/or agricultural systems
- Waste to energy



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Topic Importance: Water, Energy and Food Nexus

- **Water:**
- Wastewater (Collection / Treatment / Disposal)
- Water footprint
- Hydrology and water cycle
- **Desalination**
- Water quality and the ecosystem
- Irrigation and water use in the agri-food industry
- Recovery of energy and materials from wastewaters
- Blue economy



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Topic Importance: Water, Energy and Food Nexus

- **Agriculture:**
- Agriculture (Irrigated and Rain-Fed, Livestock, Aquaculture)
- Food industry
- Nutrients and soil
- Ecological Footprint, land use and land use change
- Biodiversity
- Plant physiology (Photosynthesis, Evapotranspiration)
- Utilization of byproducts and residues
- Bioeconomy
- Vertical farming and urban farming
- Macroalgae and microalgae cultivation



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Topic Importance: Water, Energy and Food Nexus

- **Modeling:**
- System Dynamics Modeling
- Big Data Informatics and **AI**
- Optimization models and Governance Tools
- LCA (Social LCA, LCC, eLCA)
- Input-Output LCA analysis and econometrics
- Sustainable development Policies and SDGs
- Resources and materials flow analysis through GIS and Remote sensing



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Energy and Thermodynamic analysis

- When we deal with Energy, we must take into account laws of thermodynamics



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Energy and Thermodynamic analysis

أحمد جدير ابوسلامه

ده قدر يعيد هدر الهواء
المضغوط بواسطة الحدافات الى خزان الهواء
تاني ما يعني عدم نفاذ الهواء وبالتالي دوام
استمرارية المحرك

1 d Like Reply

Mohamed Sameh

أحمد جدير ابوسلامه يا ريس بالله عليك
بلاش الكلام الفارغ ده، دوام استمرارية
المحرك ازاي يس؟ مفيش حاجة في لادنيا
اسمها كده، الطاقة لا نفس و لاتتحدت من
العدم، الطاقة التي محتاجها الكومبيوتر
عشان يشتغل اعلى بمراحل من الطاقة
التي هيطلعها الهواء المضغوط اصلا لان
فيه جزء كبير جدا هيرجح في الاحتكاك و
الحركة و تحويل الطاقة من صورة للتانية
و حتى في صوت المحرك نفسه!! هتخرج
الطاقة التي ضاعت دي ازاي؟! هتخلق...
See more

23 m Like Reply

أحمد جدير ابوسلامه

كلام حضرتك علمي
Mohamed Sameh ومنطقي وناجح من صميم شخص متمرس
ولكن استخدام حيل فيزيائية يجعل الأمور
تظهر وكأنها غوارق للعادة
لما بحتت ودفقت في الأمر ومررت عدة
تجارب رأيت انه جائز من الناحية الواقعية

12 m Like Reply

Mohamed Sameh

أحمد جدير ابوسلامه يا اقدم ، مفيش
حاجة اسمها حيل فيزيائية تكسر قوانين
الطبيعة، فيه حاجة اسمها حيل تضحك
على المشاهد وتلهم غدا انها عملت كده،
إنفا في الواقع مستحيل . التي بيكلم
حضرتك دكتور ميكانيكا في هندسة يعني
ده شغلي و عارف باقول ايه

11 m Like Reply

أحمد جدير ابوسلامه

يا هندسة انا
Mohamed Sameh بقالي فترة بحاول استحدث طاقة من
العدم (طريق تحايل)
وكان من ضمنها مولد كهرباء الدبزل اقلبه
محرك كهربائي بعد الحركة وتوليد التيار
ولكن فشلت
والهواء من غير الدائرة المغلقة فشلت
بالهواء المرتفعة جدا فشلت
واستخراج الهواء الجوفية بطريق ضغط
الهواء فشلت
ايديك معايا

2 m Like Reply



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Energy and Thermodynamic analysis

- The First Law of Thermodynamics states that total energy in a closed system is neither lost nor gained — it is only transformed.



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Energy and Thermodynamic analysis

- The Second Law of Thermodynamics
- Carnot Heat Engine
- $\text{Eta} = (T_{\text{max}} - T_{\text{min}}) / T_{\text{max}}$
- Heat Engine
- $\text{Eta} = (Q_{\text{in}} - Q_{\text{out}}) / Q_{\text{in}} = W_{\text{net}} / Q_{\text{in}}$



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Energy and Thermodynamic analysis

- The Second Law of Thermodynamics
- Carnot Heat Pump
- $\text{COP} = T_{\text{max}} / (T_{\text{max}} - T_{\text{min}})$
- Heat Pump
- $\text{COP} = Q_{\text{out}} / (Q_{\text{out}} - Q_{\text{in}}) = Q_{\text{out}} / W_{\text{in}}$



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Energy and Thermodynamic analysis

- The Second Law of Thermodynamics
- Carnot Refrigerator
- $COP = T_{min} / (T_{max} - T_{min})$
- Refrigerator
- $COP = Q_{in} / (Q_{out} - Q_{in}) = Q_{in} / W_{in}$



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Energy and Thermodynamic analysis

- Power is the rate of change of Energy
- $\text{Energy} = \text{Power} * \text{Time}$
- Units of Energy are kW.hr
- Example is The monthly electric bill



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Introduction about Energy

- Because of the continuous increase in population worldwide and the various industrial activities to provide the needs for them, a great demand for energy has resulted. The world has used fossil fuels as the primary source of energy for the previous centuries. But because of the limited quantities of fossil fuel, alternative sources of energy should be used. In addition to the environmental problems associated with the use of fossil fuels, the need to find a new source of energy has in-creased. **Therefore, renewable energy sources have been the best solution for these problems. Renewable energy sources have advantages that they will never end, and they are environment friendly (Olabi and Abdelkareem, 2022).**
- **Sustainable Energy and Environmental Protection (SEEP) conference-held at the University of the West of Scotland, UK, 2018**
- A. G. Olabi and M. A. Abdelkareem, “Renewable energy and climate change,” Renewable and Sustainable Energy Reviews, vol. 158, p. 112111, 2022.
- <https://www.sciencedirect.com/science/article/pii/S1364032122000405>



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Introduction about Energy

- Utilizing of renewable energy has been increased drastically in the last decades, as shown in Fig. 1 and Fig. 2.
- Fig. 1 shows that the percentage of producing electricity from renewable sources has increased from 18.4% in 2001 to 28.35% in 2021 from the total electricity generation worldwide. While Fig. 2 shows the increase in electricity production for each type of renewable energy sources individually.
- **Electricity production from fossil fuels, nuclear and renewables**
- <https://ourworldindata.org/grapher/elec-fossil-nuclear-renewables>
- **SDG Tracker: Measuring progress towards the Sustainable Development Goals**
- <https://ourworldindata.org/sdgs>



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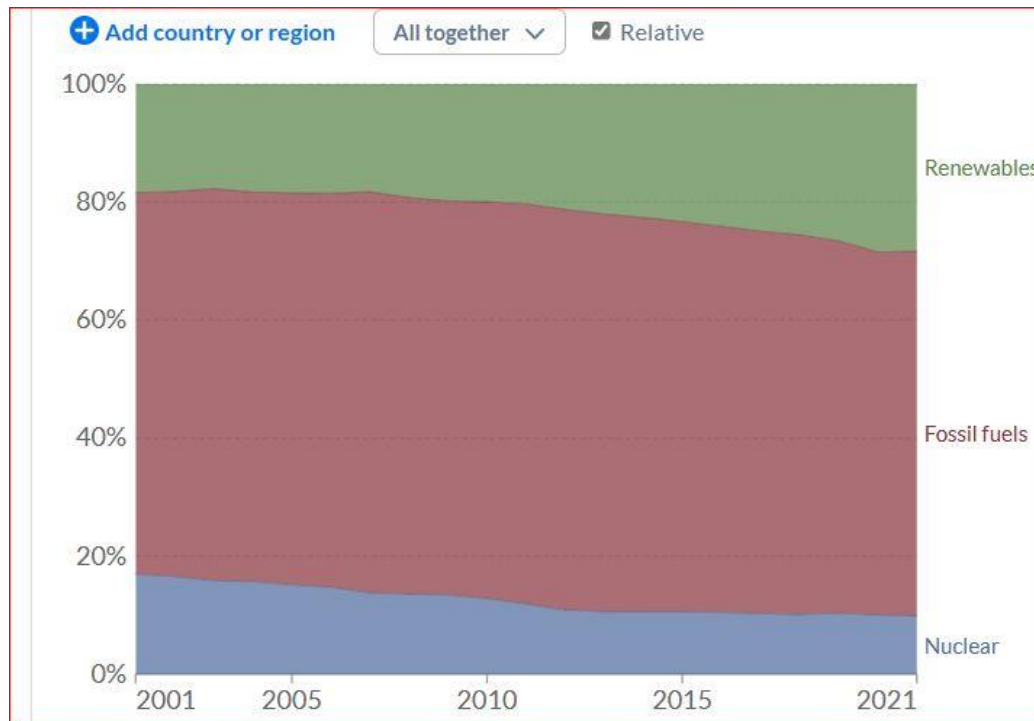


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Introduction about Energy





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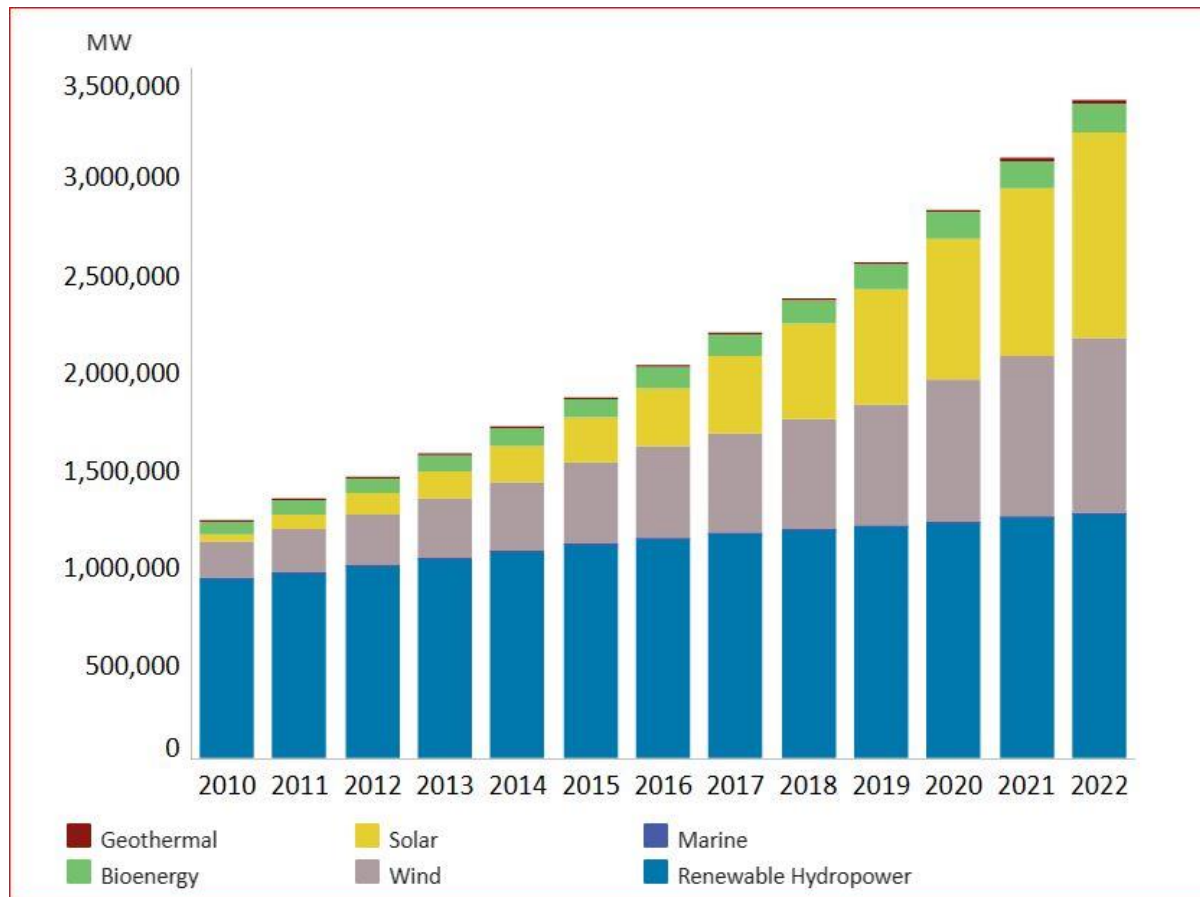


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Introduction about Energy





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Classification of energy sources

- 1-طاقة متحركة transitional
- 2-طاقة مختزنة stored
- ما هي الطاقة المتحركة؟
- الطاقة المتحركة هي الطاقة التي يمكن أن تخترق حدود النظام system boundaries
- ما هي الطاقة المختزنة؟
- الطاقة المختزنة هي الطاقة التي يمكن أن تتواجد في كتلة محددة أو موضع محدد أو مجال لقوة محددة force field



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Energy forms

- 1- الطاقة الميكانيكية T&S mechanical energy
- 2- الطاقة الكهربائية T&S electrical energy
- 3- الطاقة الكهرومغناطيسية electromagnetic energy
- 4- الطاقة الكيميائية S chemical energy
- 5- الطاقة النووية S nuclear energy
- 6- الطاقة الحرارية T&S thermal energy



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Mechanical energy

- ويمكن أن تتواجد الطاقة الميكانيكية في صورة متحركة على شكل شغل ميكانيكي mechanical work أو في صورة مختزنة كما في حالة طاقة الوضع potential energy. وطاقة الوضع يمكن أن تكون واحدة من الخمس صور التالية:



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Mechanical energy

- الطاقة الناتجة عن وضع كتلة في مجال الجاذبية الأرضية وهو التعريف الكلاسيكي لطاقة الوضع.
- الطاقة الناتجة عن وضع كتلة داخل مجال ذي قوة قصور *inertial force field* وهذا هو التعريف الكلاسيكي لطاقة الحركة.
- الطاقة التي يحتويها غاز مضغوط *compressed fluid*.
- الطاقة الناتجة عن وجود الكتلة في مجال انفعال مرن *elastic strain field*.
- الطاقة الناتجة عن وجود كتلة حديدية في مجال مغناطيسي *magnetic field*.



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Electrical energy

- حركة سيل من الإلكترونات flow of electrons عبر موصل كهربائي.
- يمكن تخزين الطاقة الكهربائية في مجال كهروستاتيكي capacitors electrostatic field كما في المكثفات وأيضاً يمكن تخزين الطاقة الكهربائية في الملفات الحثية induction coils



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Electromagnetic energy

- هي طاقة تنتج عن انتقال الموجات الكهرومغناطيسية electromagnetic waves عن طريق الإشعاع radiation
- تختلف عن الصور الأخرى في كونها تنتقل بدون وجود مادة وسيطة medium ولكن تكون في صورة أشعة متحركة بسرعة الضوء
- تختلف عن الصور الأخرى في كونها تنتقل بدون وجود مادة وسيطة medium ولكن تكون في صورة أشعة متحركة بسرعة الضوء



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Electromagnetic energy

- h = Planck constant ($6.626 \times 10^{-34} \text{ J.s}$)

$$E = h \nu = \frac{hc}{\lambda}$$



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Chemical energy

- تنتج من تفاعل الذرات أو الجزيئات مع بعضها لتكوين مواد أو مركبات أكثر استقرارا
- وهذه التفاعلات عادة تكون طاردة للحرارة
exothermic reactions. وهذا هو ما يحدث في عمليات الاحتراق combustion والتي يتم فيها حرق الوقود وتحويل الطاقة الكيميائية إلى طاقة حرارية thermal energy.
- لا تتواجد إلا في صورة مختزنة stored energy



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Nuclear energy

- تنتج من تفاعل مكونات الذرة مع النواة أو تفاعل بين المكونات نفسها
- أي أن الطاقة النووية لا تنتج إلا بتغير في تركيب نواة الذرة نفسها بخلاف التفاعل الكيميائي
- لا تتواجد إلا في صورة مختزنة



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Nuclear energy

- التحلل الإشعاعي •
Radioactive decay
- الاندماج •
Fusion
- الانشطار •



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Thermal energy

- حركة ترددية لمكونات المادة (الجزيئات والذرات) ويمكنها أن تنتقل بين الأجسام مع وجود مادة وسيطة
- والطاقة الحرارية يمكن أن تخزن في صورة طاقة كامنة latent heat أو طاقة محسوسة sensible heat.



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Energy sources

- **طاقة قادمة من خارج الأرض Income energy**
- الطاقة المعتمدة على الشمس (الطاقة الشمسية) والقمر (المد والجزر tidal energy).
- طاقة الرياح والتي تنتج عن تفاوت درجات الحرارة وضغط الهواء على سطح الأرض.
- الطاقة الحيوية biomass energy الموجودة في النباتات تنتج أيضا من الطاقة الشمسية نتيجة عملية التمثيل الضوئي photosynthesis
- التدرج الحراري في درجة حرارة المحيطات وأمواج البحر وتبخر كميات ضخمة من مياه البحار والمحيطات ثم سقوطها على شكل أمطار



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Energy sources

- Capital energy
 - الطاقة الموجودة بالفعل في الأرض مثل الوقود الحفري
fossil fuel
 - والطاقة النووية nuclear energy



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Energy Conversion

- يمكن تحويل أي صورة من صور الطاقة إلى أي صورة أخرى سواء كان ذلك بطريقة مباشرة أو غير مباشرة (المقصود بالطريقة الغير مباشرة هو مرور الطاقة بصورة بينية أو أكثر قبل الوصول للصورة المطلوبة)



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Energy Conversion

Energy Conversion



Chemical



Mechanical



Chemical



Light



Electrical



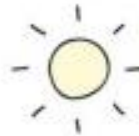
Light



Chemical



Mechanical



Light



Chemical



Electrical



Heat



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Renewable Energy in Egypt

- Ministry of Electricity and Renewable Energy
- New and Renewable Energy Authority (NREA)
- <http://nrea.gov.eg/test/en/Home>
- <http://nrea.gov.eg/>
- Annual Report – 2022 – English
- <http://nrea.gov.eg/Content/reports/Annual%20Report%202022%20Eng.pdf>
- Annual Report – 2022 – Arabic
- <http://nrea.gov.eg/Content/reports/Annual%20Report%202022%20Ar.pdf>



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Renewable Energy in Egypt

Wind Energy

- In December 2005 the Egyptian Wind Atlas was issued in cooperation with the Danish RISO Laboratories and the Egyptian Meteorological Authority (EMA) to indicate appropriate and promising areas to benefit from wind energy in generating electricity.
- The Atlas redeemed the availability of promising areas endowed with high wind speeds in Gulf of Suez and on both sides of the Nile as well as areas in Sinai which suitable for establishing large projects to generate electricity from wind energy.
- Which will qualify for the establishment of major projects to generate electricity from wind power.
- The average speed in the Gulf of Suez is about 10.5 m/s at a height of 50 meters
- The average speed in the eastern and western parts of the Nile is about 7.5 m/s at an altitude of 80 m



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Wind Energy



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Wind Energy

- HAWT
- VAWT
- Ducted wind turbines
- N. Aravindhan et al., “Performance analysis of various types of ducted wind turbines–A review,” Mater Today Proc, vol. 80, pp. 188–194, 2023.
- <https://www.sciencedirect.com/science/article/pii/S2214785322070912>



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Wind Energy

- Power = KE/time = $(0.5 * m * U^2) / \text{time}$
- Power = $0.5 * \rho * A * U^3$
- Air Wind Turbines
- Water Wind Turbines



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Wind Energy

- تقنية مذهلة.. توربينات تحت الماء تولد كهرباء 3 أضعاف الطريقة العادية (فيديو)
- https://attaqa.net/2023/07/31/%d8%aa%d9%82%d9%86%d9%8a%d8%a9-%d9%85%d8%b0%d9%87%d9%84%d8%a9-%d8%aa%d9%88%d8%b1%d8%a8%d9%8a%d9%86%d8%a7%d8%aa-%d8%aa%d8%ad%d8%aa-%d8%a7%d9%84%d9%85%d8%a7%d8%a1-%d8%aa%d9%88%d9%84%d8%af-%d9%83%d9%87/?fbclid=IwAR3XMPpObftIWJ_iyRQjVb7LZo3nGF7UG5sspdcOKDrdDa8uzVyfqTsZGFY
- TIDALWATT
- TIDALWATT On Flow Energy
- <https://www.youtube.com/watch?v=DW-DSp2od5k>



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Wind Energy

- تصنيع أطول توربين رياح خشبي في العالم (فيديو وصور)
- <https://attaqa.net/2023/08/03/%d8%aa%d8%b5%d9%86%d9%8a%d8%b9-%d8%a3%d8%b7%d9%88%d9%84-%d8%aa%d9%88%d8%b1%d8%a8%d9%8a%d9%86-%d8%b1%d9%8a%d8%a7%d8%ad-%d8%ae%d8%b4%d8%a8%d9%8a-%d9%81%d9%8a-%d8%a7%d9%84%d8%b9%d8%a7%d9%84%d9%85-%d9%81/>
- Modvion Installs Tallest Wooden Wind Power Tower in Europe
- https://www.youtube.com/watch?v=Nja_Arkyc3s



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Wind Energy

- Field visit chance to Zafarana wind farm, Suez Gulf, Egypt
- Eng. Negm



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Wind Energy

- Announcement of Wind Turbine Technology and Applications Training Courses for ITEC partner countries- Reg.



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Solar Energy

- Egypt is one of the countries of the solar belt area most suitable for applications of solar energy has been issued Atlas of the sun of Egypt, including readings have been limited for years to all regions of the Republic, and also includes a typical year in which the expected data for all days of the year, such as solar radiation and hours of sunshine.
- Atlas results show that the average direct vertical solar radiation is ranges between 2000 - 3200 kWh / m² / yr.
- The sunshine duration ranges between 9 – 11 hr/day, Which means that investment opportunities are available in various solar energy applications.



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Solar Energy + Wind Energy

- Hybrid System = Solar Energy + Wind Energy



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Other Types

- Hydro power = $\rho * g * h$
- Geothermal
- Biomass



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Other Types

- إجمالي الطاقة المتجددة. 6280 ميغاوات
- كالتالي
- رياح 1635 ميغاوات
- خلايا شمسية 1756
- هيدرو 2832
- بيوماس 56 ميغاوات



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Solar angles

- There are 10 different solar angles
- Some solar angles do not need equations for calculations such as
 - Latitude angle
 - Longitude angle
- Some solar angles need equations for calculations such as
 - Declination angle
 - Hour angle



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Solar angles

- Declination angle

$$\delta = 23.45 \sin \left[\frac{360}{365} (284 + n) \right]$$



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Solar angles

- Hour angle

$$h = \pm \frac{1}{4} (\text{number of min from local solar noon})$$



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Solar Energy Applications

Solar collectors



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Solar Energy Applications

Solar panels



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Solar Energy Applications

Solar panels



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Solar Energy Applications

Solar concentrator





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Solar Energy Applications

- Mohamed M. Awad, Auroshis Rout, Sanju Thomas, and Sudhansu S. Sahoo, 2023, “Techno-Economic Analysis of Solar Photovoltaic-Thermal System Viability,” Chapter 12 in Solar Energy Harvesting Conversion and Storage, Mohammad Khalid, Rashmi Walvekar, Hitesh Panchal, and Mahesh Vaka (Eds.), 1st Edition, Academic Press, Elsevier Inc., Philadelphia, PA, USA.
- <https://www.sciencedirect.com/science/article/abs/pii/B9780323906012000052>
- <https://www.sciencedirect.com/book/9780323906012/solar-energy-harvesting-conversion-and-storage>



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Solar Energy Applications

- Sanju John Thomas, Sheffy Thomas, Sudhansu S. Sahoo, Ajith Kumar G, and **Mohamed M. Awad**, 2023, “Solar Parks: A Review on Impacts, Mitigation Mechanism through Agrivoltaics and Techno-Economic Analysis,” Energy Nexus, Volume 11, 100220.
- <https://doi.org/10.1016/j.nexus.2023.100220>
- <https://www.sciencedirect.com/science/article/pii/S2772427123000505>



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Solar energy in providing freshwater

- K. H. Awad, M. M. Awad, A. M. Hamed, Extraction of water from atmospheric air using double slope condensation surface, Mansoura Engineering Journal (MEJ) 42 (1) (2017), 10-21, DOI: 10.21608/BFEMU.2020.97651.
- https://bfemu.journals.ekb.eg/article_97651.html
- Karim H. Awad, Mohamed M. Awad, and Ahmed M. Hamed, 2023, "Outdoor testing of double slope condensation surface for extraction of water from air," Chapter 2 in Atmospheric Water Harvesting Development and Challenges, Elvis Fosso-Kankeu, Ali Al Alili, Hemant Mittal and Bheki Bheki (Eds.), Springer.
https://link.springer.com/chapter/10.1007/978-3-031-21746-3_2
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- M. A. Talaat, M. M. Awad, E. B. Zeidan, A. M. Hamed, Solar powered portable apparatus for extracting water from air using desiccant solution, Renewable Energy 119 (2018), 662-674.
- <https://www.sciencedirect.com/science/article/pii/S0960148117312545>
- M. H. Fathy, M. M. Awad, E. B. Zeidan, A. M. Hamed, Solar powered foldable apparatus for extracting water from atmospheric air, Renewable Energy 162 (2020), 1462-1489.
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Solar energy in providing freshwater

- <https://drive.google.com/file/d/1ecmDIlzEGqzisB2PJ4wjonAxNOuHfoS/view?usp=sharing>
- https://drive.google.com/file/d/1DyitK9Y2mh1QC_3WamawOWBfnLUrFDRX/view?usp=sharing



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Solar energy in providing freshwater

- Ahmed E. Abu El-Maaty, Mohamed M. Awad, Gamal I. Sultan, Ahmed M. Hamed, 2019, “Solar Powered Fog Desalination System”, Desalination, Volume 472, Article No. (114130), doi: 10.1016/j.desal.2019.114130.
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- Ahmed E. Abu El-Maaty, Mohamed M. Awad, Gamal I. Sultan, Ahmed M. Hamed, 2021, “Performance Study of Fog Desalination System Coupled With Evacuated Tube Solar Collector”, Desalination, Volume 504, Article No.114960.
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- <https://doi.org/10.3390/en16093957>
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- https://www.mdpi.com/journal/energies/special_issues/Applied_Solar_Thermal_Energy
- <https://drive.google.com/file/d/15pvtqTzFKFDtoalqQH4zVgZUkKLlqTH2/view?usp=sharing>



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Solar energy in providing freshwater

- تحلية المياه بالطاقة الشمسية باستخدام الضباب.. تقنية مصرية جديدة
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