
PERAN PENELITIAN MATERIAL UNTUK ENERGI TERBARUKAN AKSELERATOR MENUJU SOCIETY 5.0

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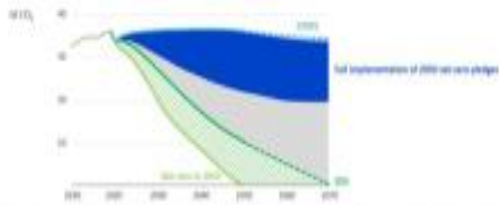
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ABSTRAK

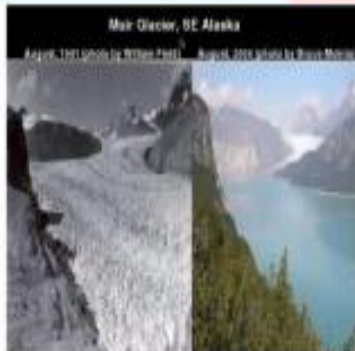
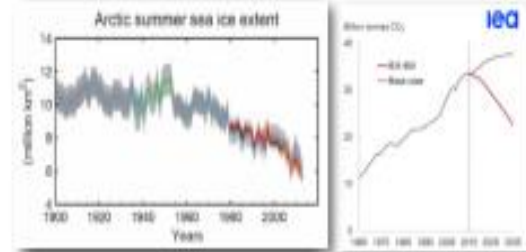
Pemerintah Indonesia telah mendukung dan berkomitmen pengurangan emisi karbon atas upaya mandiri sebanyak 29% atau dengan bantuan internasional sebanyak 41% pada tahun 2030. Kondisi saat ini, angka implementasi energi baru dan terbarukan di Indonesia secara kapasitas terpasang masih rendah dibandingkan beberapa negara ASEAN seperti Thailand, Malaysia, dan Philipina. Oleh karena itu, diperlukan pemanfaatan teknologi baru dan penelitian khususnya di sektor material untuk energi dan kelistrikan untuk mencapai target *low carbon economy* tersebut. Penelitian material untuk energi terbarukan dapat dilakukan dengan memprioritaskan dan mengoptimalkan potensi sumber daya lokal dan pemanfaatan material sekunder (limbah) termasuk limbah biomasa, limbah industri yang memiliki kandungan mineral berharga (mill scale, aluminium dross, zinc dross), seperti unsur logam tanah jarang atau unsur esensial lain untuk aplikasi energi terbarukan. Langkah tersebut dinilai sebagai pendekatan yang dari segi dampak lingkungan dan jaminan ketersediaan suplainya relatif aman, sekaligus menjawab masalah lingkungan akibat kegiatan industri atau dari aktivitas lainnya. Potensi pengembangan material tersebut dapat diolah sampai hilir untuk aplikasi elektronik, baterai, magnet, katalis, *green hydrogen*, fuel cell dan energi baru terbarukan lainnya. Strategi ini diharapkan akan mengakselerasi implementasi teknologi energi terbarukan dan sekaligus menciptakan nilai baru yaitu terbentuknya berbagai model bisnis energi dengan ditopang data digital seperti pemanfaatan big data dalam konteks energi untuk suplai energi yang efisien, bersih, handal dan terjangkau. Tatanan masyarakat inilah yang sedang dituju dunia Society 5.0, dimana energi terbarukan menjadi salah satu pilar utama keberhasilan untuk mewujudkannya.

Keywords: *Penelitian, Material; Energi terbarukan; Society 5.0*

The world is still far from putting emissions into decisive decline... **iea**



There remains significant near-term uncertainty about how emissions evolve in the aftermath of the pandemic, but unless recoveries are sustainable, the world will remain a long way from reaching climate targets.



KBRARU POCC (Clayton, Borneo) - 10 million ton of CO₂/year

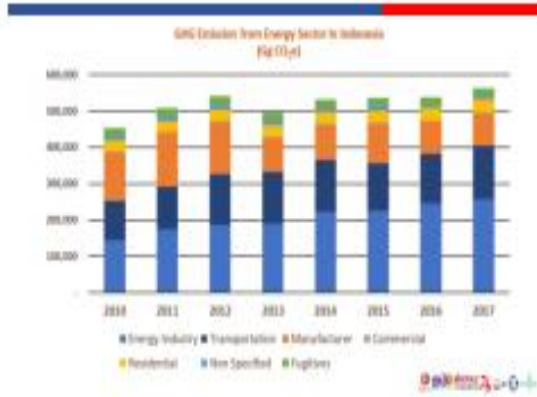


0.5 to 200
1.8 million ton
CO₂/year



Shared CO₂ infrastructure can accelerate deployment **iea**






ENERGY TRANSITION

What do we know about hydrogen

Hydrogen as "missing link" for energy transition toward deep decarbonization



- Considered clean energy and non-toxic
- Occurs naturally in the atmosphere
- Usually found in other elements or atoms
- Separating hydrogen needs more energy to be able to store it

Key challenge: Clean cost of renewable energy and non-toxic emissions, hydrogen is more expensive than other energy sources and it is more difficult to store and transport.

Fuel Cell Vehicle



TOYOTA MIRAI

200 HP (147 kW) / 2044HP

200 HP (147 kW) / 200 ENGINE




FCEV is more complex to manufacture than BEV but give a numerous advantage, including longer range and lighter in terms of weight, and rapid refueling (3 minutes)

Green Hydrogen



1. Developable technologies to produce clean electricity
2. Decarbonization of hydrogen production and chemical industry

Key challenge: Hydrogen is high cost because production, distribution and storage are still costly. Need to develop technology, infrastructure, and regulatory, standard, safety, security, and heavy regulatory technology.



POTENSI VS KAPASITAS TERPASANG EBT

	Total Terpasang (2018) GW	Total Potensial (2018) GW (2011 tahun 2020)
DIKURUSIA	17,9 GW	0 NPA ¹ (0%)
PANAS BUMI	23,9 GW	2.130,7 NPA (8,9%)
BIKIN/BIK	32,5 GW	1.983,5 NPA (5,8%)
SAYU	60,8 GW	254,3 MW (0,3%)
HEKSI	94,8 GW	6.121 MW (0,6%)
SURTA	207,8 GW	151,8 NPA (0,07%)

¹ NPA: Net Potential Available

Penyakit-penyakit tersebut:

- 1. Penyakit-penyakit tersebut
- 2. Penyakit-penyakit tersebut
- 3. Penyakit-penyakit tersebut
- 4. Penyakit-penyakit tersebut
- 5. Penyakit-penyakit tersebut



Critical minerals in the energy transition



Minerals Required For Green Energy Technologies

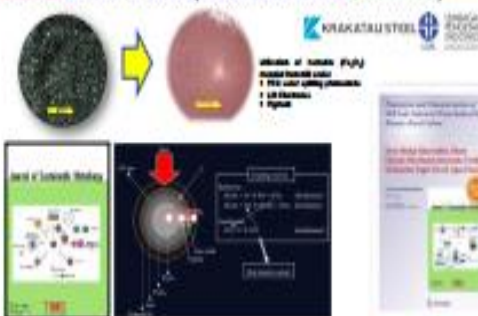
- Solar PVs** use silicon, tellurium, gallium and indium.
- Fuel cells** use elements from the platinum group.
- EV batteries and energy storage** use lithium and cobalt.
- Wind turbines and EVs** use neodymium, europium, neodymium, and yttrium.

Source: International Institute for Sustainable Development (IISD)

Mineral	Group	Applications
Bismuth	Metals	Lead-acid batteries, Solar PVs
Cadmium	Metals	Solar PVs
Indium	Metals	Solar PVs
Neodymium	Metals	Wind turbines, EVs
Platinum	Metals	Fuel cells
Tellurium	Metals	Solar PVs
Yttrium	Metals	Wind turbines, EVs
Zinc	Metals	Lead-acid batteries
Other	Metals	Various applications



HEMATITE FROM MILL SCALE (SECONDARY MATERIAL/RECYCLING)

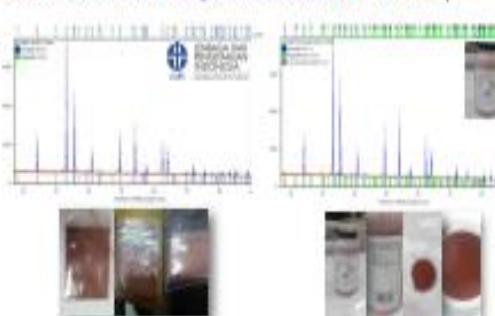


HEMATITE FROM MILL SCALE (SECONDARY MATERIAL/RECYCLING)

Process flow: Mill Scale → Hematite → Iron and Steel Making.

Source: KIRKSTADT STEEL

HEMATITE FROM MILL SCALE (SECONDARY MATERIAL/RECYCLING)



XRD patterns showing the crystalline structure of hematite. The patterns show characteristic peaks for Fe₂O₃.

Source: KIRKSTADT STEEL

LITHIUM BATTERY MERAH PUTIH



The infographic details the production of Lithium Battery Merah Putih, highlighting the use of local raw materials and the resulting battery products for various applications.

Produk Turunan Ter Batubara

CTI Produk Karbon, dan batubara, dimana gulf antara digunakan oleh industri dalam proses yang berkelanjutan untuk membuat.



- Batubara adalah sumber energi yang penting. Prosesnya menghasilkan produk turunan yang dapat digunakan oleh CTI.
- Batubara adalah sumber energi yang penting dalam industri.
- Produk turunan yang dihasilkan dari batubara adalah:
- The production of carbon products is a sustainable process.

PEMANFAATAN SUMBER DAYA LOKAL INDONESIA



The map illustrates the geographical distribution of key local resources in Indonesia, including CaCO_3 , ZnO , and Fe_2O_3 , and their potential applications in various industries.

H₂ based fuel cell

- Single-cell dan multi-cell
- Operation temperature (60-80°C)



Parameter	Value
Operating Temperature	60-80°C
Operating Pressure	1-10 bar
Operating Humidity	30-80%
Operating Current	0.5-1.0 A
Operating Voltage	0.6-1.0 V
Operating Power	0.3-1.0 W
Operating Efficiency	40-60%
Operating Lifetime	10,000 hours
Operating Cost	~\$100/kWh

Riset pengembangan elektronika daya fuel cell

Salah satu tujuan utama penelitian ini adalah untuk mengembangkan elektronika daya yang dapat digunakan untuk aplikasi fuel cell.



The research focuses on developing power electronics for fuel cell applications, including the design and testing of power converters and control systems.

Bipolar plate component material and design development

Bipolar plate based on carbon-carbon composite has been made with utilization of low-cost graphite electrode waste obtained from electric arc furnace.



The study explores the use of low-cost graphite electrode waste from electric arc furnaces as a material for bipolar plates in fuel cell stacks.

Pembuatan lembaran karbon untuk aplikasi elektroda PEMFC
 (pilihan adalah karbon aktif, grafit, atau karbon berpori)

Referensi: [1] S. S. Kim, et al., J. Power Sources, 2005, 145, 1-10. [2] M. S. Kim, et al., J. Power Sources, 2006, 157, 1-10. [3] M. S. Kim, et al., J. Power Sources, 2007, 168, 1-10. [4] M. S. Kim, et al., J. Power Sources, 2008, 179, 1-10. [5] M. S. Kim, et al., J. Power Sources, 2009, 190, 1-10. [6] M. S. Kim, et al., J. Power Sources, 2010, 201, 1-10. [7] M. S. Kim, et al., J. Power Sources, 2011, 212, 1-10. [8] M. S. Kim, et al., J. Power Sources, 2012, 223, 1-10. [9] M. S. Kim, et al., J. Power Sources, 2013, 234, 1-10. [10] M. S. Kim, et al., J. Power Sources, 2014, 245, 1-10. [11] M. S. Kim, et al., J. Power Sources, 2015, 256, 1-10. [12] M. S. Kim, et al., J. Power Sources, 2016, 267, 1-10. [13] M. S. Kim, et al., J. Power Sources, 2017, 278, 1-10. [14] M. S. Kim, et al., J. Power Sources, 2018, 289, 1-10. [15] M. S. Kim, et al., J. Power Sources, 2019, 300, 1-10. [16] M. S. Kim, et al., J. Power Sources, 2020, 311, 1-10. [17] M. S. Kim, et al., J. Power Sources, 2021, 322, 1-10. [18] M. S. Kim, et al., J. Power Sources, 2022, 333, 1-10. [19] M. S. Kim, et al., J. Power Sources, 2023, 344, 1-10. [20] M. S. Kim, et al., J. Power Sources, 2024, 355, 1-10.

Green hydrogen based on Fe₃O₄ and ZnO photoanode for cost effective photoelectrochemical (PEC) water splitting

Electrode based PEC water splitting system

Referensi: [1] S. S. Kim, et al., J. Power Sources, 2005, 145, 1-10. [2] M. S. Kim, et al., J. Power Sources, 2006, 157, 1-10. [3] M. S. Kim, et al., J. Power Sources, 2007, 168, 1-10. [4] M. S. Kim, et al., J. Power Sources, 2008, 179, 1-10. [5] M. S. Kim, et al., J. Power Sources, 2009, 190, 1-10. [6] M. S. Kim, et al., J. Power Sources, 2010, 201, 1-10. [7] M. S. Kim, et al., J. Power Sources, 2011, 212, 1-10. [8] M. S. Kim, et al., J. Power Sources, 2012, 223, 1-10. [9] M. S. Kim, et al., J. Power Sources, 2013, 234, 1-10. [10] M. S. Kim, et al., J. Power Sources, 2014, 245, 1-10. [11] M. S. Kim, et al., J. Power Sources, 2015, 256, 1-10. [12] M. S. Kim, et al., J. Power Sources, 2016, 267, 1-10. [13] M. S. Kim, et al., J. Power Sources, 2017, 278, 1-10. [14] M. S. Kim, et al., J. Power Sources, 2018, 289, 1-10. [15] M. S. Kim, et al., J. Power Sources, 2019, 300, 1-10. [16] M. S. Kim, et al., J. Power Sources, 2020, 311, 1-10. [17] M. S. Kim, et al., J. Power Sources, 2021, 322, 1-10. [18] M. S. Kim, et al., J. Power Sources, 2022, 333, 1-10. [19] M. S. Kim, et al., J. Power Sources, 2023, 344, 1-10. [20] M. S. Kim, et al., J. Power Sources, 2024, 355, 1-10.

Green hydrogen for... catalyst... electrolysis... plat

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"Bangsa yang tidak percaya pada kekuatan dirinya sebagai suatu bangsa, tidak dapat berdiri sebagai suatu bangsa yang merdeka."

Soekarno

Terima Kasih

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