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## PERAN PENELITIAN MATERIAL UNTUK ENERGI TERBARUKAN AKSELERATOR MENUJU SOCIETY 5.0

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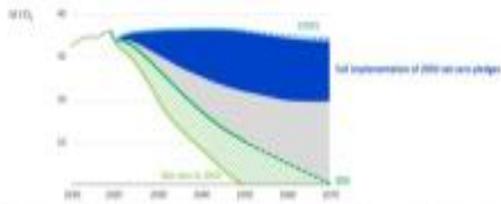
### ABSTRAK

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.

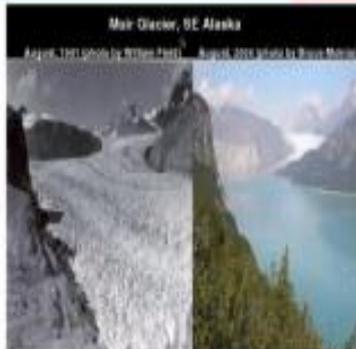
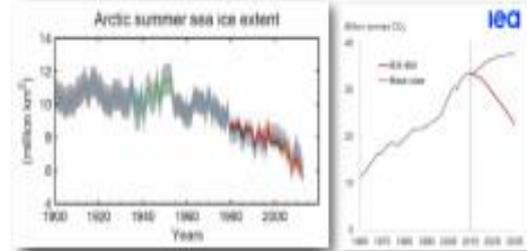
Keywords: *Penelitian, Material; Energi terbarukan; Society 5.0*



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

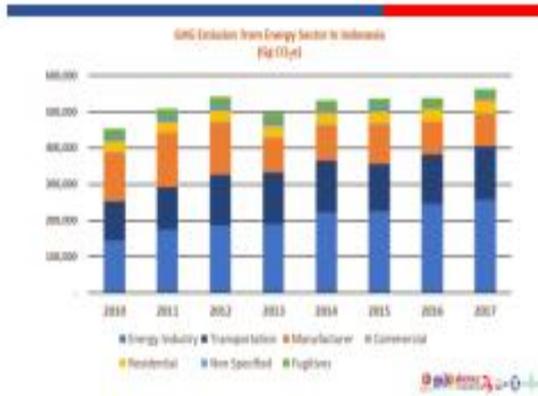


0.5 to 200  
1.8 million ton  
CO2/year



Shared CO<sub>2</sub> 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: High cost of infrastructure and low energy efficiency. Hydrogen is a clean energy carrier that needs to be produced and stored efficiently.

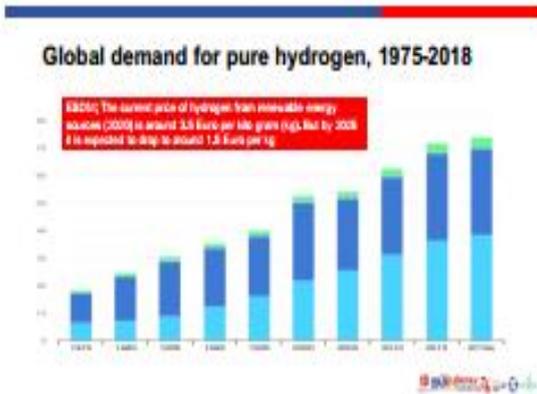
### Fuel Cell Vehicle

Key features: High efficiency, low emissions, and long range.

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



### POTENSI VS KAPASITAS TERPASANG EBT

	Total Terpasang (MW)	Total Potensial (MW)
JAWA BARU	17,9 MW	0 MW (0%)
PANJAS BARU	23,9 MW	2.180,7 MW (9,3%)
BANJAWARI	32,5 MW	1.983,5 MW (6,1%)
SUMBA	60,8 MW	254,3 MW (0,4%)
DIY	94,8 MW	6.121 MW (6,5%)
RIAU	207,8 MW	151,8 MW (0,7%)

**Kelebihan energi terbarukan:**

- Kebersihan lingkungan.
- Keuntungan jangka panjang (tidak terpengaruh oleh perubahan iklim).
- Keuntungan sosial (keberlanjutan & aksesibilitas).
- Keuntungan ekonomi (tidak memerlukan biaya modal yang tinggi).
- Keuntungan kesehatan (tidak menimbulkan pencemaran).



### Critical minerals in the energy transition

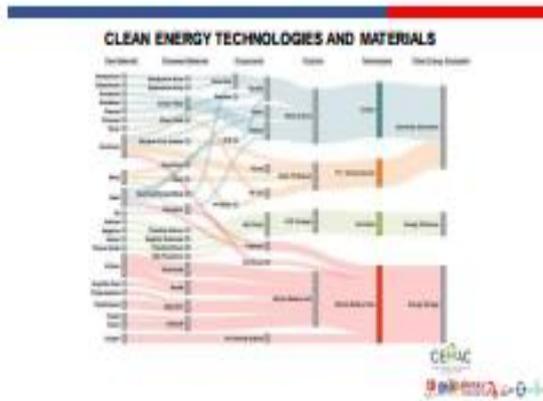


**Minerals Required For Green Energy Technologies**

- 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
Berthelium	Alkali	Alkali
Calcium	Alkaline Earth	Alkaline Earth
Chromium	Transition	Transition
Cobalt	Transition	Transition
Copper	Transition	Transition
Europium	Lanthanide	Lanthanide
Gallium	Post-transition	Post-transition
Indium	Post-transition	Post-transition
Iron	Transition	Transition
Lithium	Alkali	Alkali
Neodymium	Lanthanide	Lanthanide
Platinum Group Metals	Transition	Transition
Silicon	Metalloid	Metalloid
Tellurium	Chalcogen	Chalcogen
Yttrium	Lanthanide	Lanthanide

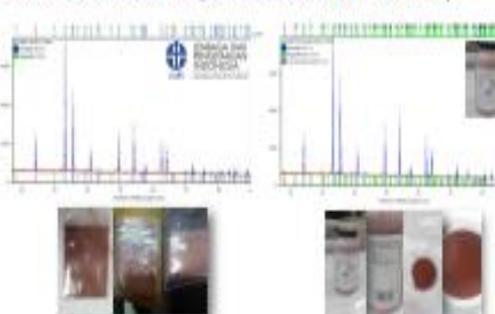


### HEMATITE FROM MILL SCALE (SECONDARY MATERIAL/RECYCLING)



Source: KIRKSTADT STEEL

### HEMATITE FROM MILL SCALE (SECONDARY MATERIAL/RECYCLING)



### LITHIUM BATTERY MERAH PUTIH



The diagram illustrates the production process of Lithium Batteries, categorized into three stages: **Material**, **Production**, and **Product**. It shows various components like cathodes, anodes, and electrolytes, and their assembly into different battery types such as cylindrical, prismatic, and pouch cells.

### Produk Turunan Ter Batubara

CTI Produk Karbon, dan hasil serbuk, dimana gulf untuk digunakan oleh industri baterai primer yang berkelanjutan semakin meningkat.



- Hasil CTI saat ini khusus digunakan pada industri baterai primer yang berkelanjutan.
- Hasil serbuk yang lebih banyak akan digunakan oleh industri baterai primer yang berkelanjutan.
- Hasil serbuk yang lebih banyak akan digunakan oleh industri baterai primer yang berkelanjutan.
- Hasil serbuk yang lebih banyak akan digunakan oleh industri baterai primer yang berkelanjutan.

### PEMANFAATAN SUMBER DAYA LOKAL INDONESIA



The map highlights the distribution of local resources in Indonesia, including  $\text{CaCO}_3$  (limestone),  $\text{ZnO}$  (zinc oxide), and  $\text{Fe}_2\text{O}_3$  (iron oxide). It also shows the location of the CTI (Central Technology Institute) in Semarang.

### H<sub>2</sub> based fuel cell

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



Parameter	Value
Operating Temperature	60-80°C
Operating Pressure	1-2 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

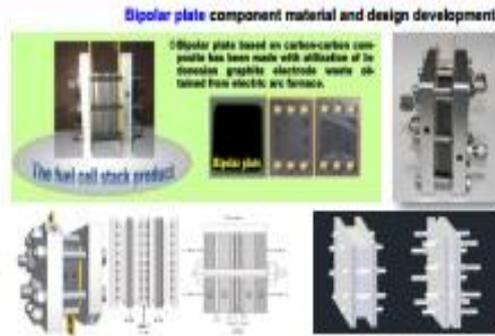
Carroll Hertz merupakan teknologi untuk dan elektronik fuel cell yang menggunakan energi kimia yang terkandung di dalam sel bahan bakar.



The research focuses on the development of power electronics for fuel cells, including the design of power MOSFETs and the implementation of a power MOSFET driver.

### Bipolar plate component material and design development

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



The image shows the bipolar plate component material and design development, including a fuel cell stack product and a bipolar plate component.

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

Referensi: [1] [2] [3] [4] [5] [6] [7] [8] [9] [10] [11] [12] [13] [14] [15] [16] [17] [18] [19] [20] [21] [22] [23] [24] [25] [26] [27] [28] [29] [30] [31] [32] [33] [34] [35] [36] [37] [38] [39] [40] [41] [42] [43] [44] [45] [46] [47] [48] [49] [50] [51] [52] [53] [54] [55] [56] [57] [58] [59] [60] [61] [62] [63] [64] [65] [66] [67] [68] [69] [70] [71] [72] [73] [74] [75] [76] [77] [78] [79] [80] [81] [82] [83] [84] [85] [86] [87] [88] [89] [90] [91] [92] [93] [94] [95] [96] [97] [98] [99] [100]

**Green hydrogen based on  $\text{Fe}_2\text{O}_3$  and ZnO photoanode for cost effective photoelectrochemical (PEC) water splitting**

Electrode based PEC water splitting system

Referensi: [1] [2] [3] [4] [5] [6] [7] [8] [9] [10] [11] [12] [13] [14] [15] [16] [17] [18] [19] [20] [21] [22] [23] [24] [25] [26] [27] [28] [29] [30] [31] [32] [33] [34] [35] [36] [37] [38] [39] [40] [41] [42] [43] [44] [45] [46] [47] [48] [49] [50] [51] [52] [53] [54] [55] [56] [57] [58] [59] [60] [61] [62] [63] [64] [65] [66] [67] [68] [69] [70] [71] [72] [73] [74] [75] [76] [77] [78] [79] [80] [81] [82] [83] [84] [85] [86] [87] [88] [89] [90] [91] [92] [93] [94] [95] [96] [97] [98] [99] [100]

**Green for** **Research** **Journal**

Generating clean hydrogen fuel using scrap aluminum and water

**Effect of Mg and Zn Doping on Hydrogen Generation via Reduction of Manganese Dioxide in Alkaline**

Referensi: [1] [2] [3] [4] [5] [6] [7] [8] [9] [10] [11] [12] [13] [14] [15] [16] [17] [18] [19] [20] [21] [22] [23] [24] [25] [26] [27] [28] [29] [30] [31] [32] [33] [34] [35] [36] [37] [38] [39] [40] [41] [42] [43] [44] [45] [46] [47] [48] [49] [50] [51] [52] [53] [54] [55] [56] [57] [58] [59] [60] [61] [62] [63] [64] [65] [66] [67] [68] [69] [70] [71] [72] [73] [74] [75] [76] [77] [78] [79] [80] [81] [82] [83] [84] [85] [86] [87] [88] [89] [90] [91] [92] [93] [94] [95] [96] [97] [98] [99] [100]

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

*Sudirman*

Referensi: [1] [2] [3] [4] [5] [6] [7] [8] [9] [10] [11] [12] [13] [14] [15] [16] [17] [18] [19] [20] [21] [22] [23] [24] [25] [26] [27] [28] [29] [30] [31] [32] [33] [34] [35] [36] [37] [38] [39] [40] [41] [42] [43] [44] [45] [46] [47] [48] [49] [50] [51] [52] [53] [54] [55] [56] [57] [58] [59] [60] [61] [62] [63] [64] [65] [66] [67] [68] [69] [70] [71] [72] [73] [74] [75] [76] [77] [78] [79] [80] [81] [82] [83] [84] [85] [86] [87] [88] [89] [90] [91] [92] [93] [94] [95] [96] [97] [98] [99] [100]

**Terima Kasih**

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