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Tim Patterson
CEO, Economy Solution Group

"Greening of Coal: Towards Zero Emission"

13th WORLD PETRO COAL CONGRESS
International Conference on Petroleum-Coal-Gas
15-16 February 2023 | New Delhi - India

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Summary of Presentation

1. Proven clean coal focus (as Fuel Economy Solution)
2. Coal Economy Transformation
3. What is greening of coal?
4. Low hanging fruit – decarbonisation steps
5. More difficult challenges – history of CC(US)
6. Ongoing and planned research & timelines
7. Is Greening of Coal to Zero Emission Possible? Conclusions

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1. Proven Clean Coal Focus

- Track record going back ten years working on clean coal
- E.g. Institute for Eastern Institute of Studies Foundation
- Role in discussion panels, moderating and panel partners
- 10th Investment Forum, Tarnow – Plenary session

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Proven Clean Coal Focus

- **10th Investment Forum, (Tarnow, Poland)**

16:10 - 17:25 PLENARY SESSION **ZLOTA HALL**

Innovation in Market Economy – How to Achieve This?

- *What further actions on the side of the state can be expected by Polish innovators?*
- *How will the Strategy for Responsible Development bring startups closer to corporations and what is the most pressing challenge?*
- *How do other European countries support innovation? Examples of good practices*

Moderator:

- **Roman Ciepiela** - Mayor, City of Tarnow, Poland

Speakers:

- **Grzegorz W. Kolodko** - Professor, Kozminski University, Poland
- **Jacek Krupa** - Marshal, Malopolska Region Marshal's Office, Poland
- **Tim Patterson** - CEO, Fuel Economy Solution Limited, United Kingdom
- **Christina Teipen** - Professor, The Berlin School of Economics and Law, Germany

Coal as an Opportunity for Technological and Scientific Progress – debate during 10th Investment Forum

Clear coal – is it possible? What are examples of innovations in limiting the harmful effects of coal economy? What is Poland's potential in view of world's trends? Participants of the discussion will be looking for answers to these and other questions during the panel discussion „Coal as an Opportunity for Technological and Scientific Progress", which takes place within 10th Ivestment Forum in Tarnow, (24-25 April).

The discussion will be attended by:

Tim Patterson, CEO, Fuel Economy Solution Limited, United Kingdom
Mykola Voytiv, Head, NGO New Generation Management, Ukraine
Maciej Rys, Founder & Leader, Smogathon, Poland
Miroslaw Taras, Vice-President, PD Co Sp. z o.o, Poland
Zbigniew Kasztelewicz, Head of Surface Mining Department, AGH University of Science and Technology in Cracow, Poland

The panel discussion will be moderated by **Zbigniew Kasztelewicz**, Head of Surface Mining Department, AGH University of Science and Technology in Cracow, Poland

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Proven Clean Coal Focus

- **3rd Industry Forum, Karpacz (Forum Panel partner)**

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3rd Industry Forum: Clean Coal Panel Partner

Partners

arp · Air Liquide · FAMUR · FIBARO · ORLEN · materialise · SUPRA BROKERS · Walter Herz · RAFAMET · Staropolanka · Hotel Gołębiewski

Institutional Partners

Fuel Economy Solution

The project is co-financed by the Minister of Economic Development and Finance of the Republic of Poland

Polska

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3rd Industry Forum: Clean Coal Panel Partner

December 8

Innovations - Room 6.30

19:35 - 21:00 THEMATIC BLOCK

Cleaner Coal - Is It Achievable?

Cleaner combustion of coal using combustion efficiency technologies will bring improved energy security to many countries, including Poland. What are the technical challenges to achieving this? What role should the state play in encouraging innovative research and retrofit aftermarket technologies to boost thermal efficiencies in coal fired power stations?

Partner: **Fuel Economy Solution Limited**

EXHIBITOR PRESENTATION

ASPOL-FV

STORIES OF SUCCESS

Special guest:

- **Roman Ciepiela** - Mayor, City of Tarnow, Poland

Host:

- **Jan Krzysztof Bielecki** - Chairman of the Partners Board, EY, Poland

DISCUSSION PANEL

Cleaner Coal - Is It Achievable?

Moderator:

- **Karol Tokarczyk** - Journalist, Polish Radio, Poland

Speakers:

- **Pedro Iglesia** - President, CARBUNION, Spain
- **Lukasz Kasztelowicz** - President of the Board, The Regional Fund for Environmental Protection & Water Management in Wroclaw, Poland
- **Tim Patterson** - CEO, Fuel Economy Solution Limited, United Kingdom
- **Robert Winnicki** - Member, Parliament, Poland

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Proven Clean Coal Focus

- UK DIT mining trade missions – GIG, PGG, JSW, KGHM
- Central Mining Institute (GIG) in Katowice
- Large R&D laboratory testing facility
- 20 pilot test facilities at Zabrze
- Experimental mine (Barbara)

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Proven Clean Coal Focus

- UK Green Pavilion special energy events COP 22 & 23
- First clean coal meeting in India in Kolkata in 2018
- During Covid we started with a clean coal tech partner
- This complimented our technology and business goals
- Economy Solution Group officially launched Nov 21
- Coal Economy Solution Limited launched Jan 2022
- Other subsidiaries include Finance – key to clean coal
- At the 10th WPCC Feb '20 we called for *Transition Bonds*

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2. Coal Economy Transformation

- An *economic* event not just environmental
- The transformation must support industry & society
- Backfill coal with reliable base load energy source(s)
- Too fast = energy insecurity, economic slowdown
- Renewables failure backstop 2050 = M/S/AMR Nuclear
- 90% world's cement comes from coal
- 70% world's steel comes from coal
- 50% world's aluminium comes from coal

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Transformation Example: Cement

- Key strategies to cut carbon emissions:
- Improving energy efficiency
- Low carbon fuels
- Promoting material efficiency
- e.g. Reduce Clinker-to -cement ratio & lower demand
- Advancing innovative near zero emission production
- These last 2 require something that doesn't yet exist!*
- (*Cement – Analysis – IEA)

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3. What is Greening of Coal?

- Reduce emissions from actual coal mining and processing
- These areas include coal mine vehicles & auxiliary power
- Reduce emissions by using less coal – reduce demand?
- Improve combustion in the power generation process
- Enhancing recovery of by products to increase savings
- CCUS necessary but previously unsuccessful at scale
- First we need low cost carbon capture at scale
- *Then* we need utilisation integrated with clean transition
- Displace with reliable base load from Renewables/SMRs

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Low Hanging Fruit – Decarbonisation Steps

Coal Activation System

Significant Reduction in Coal Consumption & Emissions

Non-Toxic, Non-Hazardous, Non-Corrosive

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Low Hanging Fruit – Decarbonisation Steps

Coal Activation System Features:

- Uses quantum nano water and EM-laser coal activation
- Utilizes the elemental, not chemical nature of key, non-hydrocarbon substances in coal
- This creates a much improved combustion rate
- Result: Lower coal feedstock costs & lower emissions

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Low Hanging Fruit – Decarbonisation Steps

Coal Activation System Key Factors:

- Reduces the toxic, carcinogenic emissions (Dioxins, Furans, etc.) from coal-fired power plants by greater than 95%, CO by over 70% and CO_2 by 40%.
- The Technology also reduces coal usage by 15-20% for the same amount of electric output.
- Currently on offer to electric utilities at no upfront cost
- Coal Economy Solution &/partners would fund retrofit

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Low Hanging Fruit – Decarbonisation Steps 1

- **Combustion efficiency CFPP retrofit**
- Best applied to pulverised coal power plants
- 2 pilot industrial tests proved 15-20% less coal required
- Non linear higher 40% CO2 saving
- Uses nano-catalysts and laser activation technology
- First two installations going into ASEAN starting 1H/23
- Coal Economy Solution first India retrofit planned Q4/23
- Finance currently being arranged, CFPP site TBC

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Low Hanging Fruit – Decarbonisation Steps 1

- **Combustion efficiency CFPP retrofit**
- Two modules
- Module I is in the combustion
- Module II is targeting flue gases
- Emissions reduction not linear with coal saving

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Low Hanging Fruit – Decarbonisation Steps 1

- **Combustion efficiency CFPP retrofit - Features**
- Allows for the manipulation of several physical properties
- Lowering ignition temperature of the coal
- Increasing the thermal output
- Lowering energy required to heat a given volume of H_2O
- System also allows for the addition of a mineral matrix and proprietary lasers in the emissions stack
- This results in significant reduction in harmful carcinogenic and toxic emissions

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Low Hanging Fruit – Decarbonisation Steps 1

- **Combustion efficiency CFPP retrofit – Benefits**
- Initial conditioning removing slag and deposits
- Increased boiler efficiencies - higher BTU output
- Reduces SOx, Nox, CO, CO2 and PM output
- Lower workload all back end equipment
- Reduced solids recovery for waste
- Low retrofit costs to apply catalyst to coal
- Suitable for most popular – pulverised CFPPs.

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Low Hanging Fruit – Decarbonisation Steps 1

- **Combustion efficiency CFPP retrofit – results so far**

Summary of Tests Results*			
Coal Technology Tests (2004 to 2019)	Year	Fuel Saving**	Avg. Emissions***
Beta Lab Tests – Single System	2004	8%	15%
European University Lab Tests	2005-2008	8-12%	20%+
Small Coal Boiler Tests (CEE)	2006-2007	13-15%	+ 30%+
Large Scale Coal Power Plant Tests (200+ MW) (CEE)	2006-2009	12-18%	+ 30%+
Specific Emissions Test (Module II)	2006-2021	N/A	+ 90%+

Notes:

* The table is an average summary of a wide range of results during the past 17 years. Official results can be viewed after an NDA and MOU is signed.

** The Fuel Saving is an average of a wide range of tests that were performed over a long period. In general, the coal technology has been advancing over time with an ever increase in fuel savings achieved.

*** The Average Emissions shows a blended emission profile savings. Generally, CO_2 savings are directly related to the saving of fuel, whereas improved combustion also lead to further reductions in CO, HC and PM5, PM10. Therefore, the blended emissions saving profile Is larger than the pure Fuel saving (which corresponds more directly with CO_2 saving). Furthermore, Module II (i.e., smokestack treatment) achieved further reductions in CO_2, and especially in PM 5, PM10 and cancerous emissions.

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Low Hanging Fruit – Decarbonisation Steps

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- The Technology also reduces coal usage by 15-20% for the same amount of electric output.
- Currently on offer to electric utilities at no upfront cost
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Low Hanging Fruit – Decarbonisation Steps

Coal Activation System – More Key Factors:

- No down time for the plant to install equipment/tech
- Installation *can* occur when the plant is offline for routine maintenance, or
- Partially installed while the plant is operating with full installation completed during the next scheduled maintenance.
- The Technology can make a coal-fired power plant's emissions as 'clean' as a gas-fired power plant.
- The parties will share in the coal savings and carbon credits generated from the Coal Activation Technology installation.

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Low Hanging Fruit – Decarbonisation Steps 2

- **Combustion efficiency - equipment**
- Fuel Economy Solution combustion chamber catalysts
- Hybrid diesel power gensets with energy storage
- New 2H injection retrofit technology being assessed
- **Improved silver recovery (from fly ash)**
- Plasma arc thermal lance technology (at up to 3,000 ^{o}C)
- Method can be used for tailings and e-Waste as well
- First plants seeking funding Q2/23 in USA
- Finance Economy Solution working on raises and licences

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A Pathway Study For India

- Determine a pathway for reducing CO_2 and other emissions such as SOx, NOx and particulates from the power sector in India out to 2040 covering:
- Establishing and implementing policies for change
- Increasing flexibility and efficiency of the coal power fleet
- Improving air quality with robust standards and control technologies
- CCS/CCUS capacity building, leading towards technology introduction, both for coal power and large industrial processes

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5. More Difficult Challenges – History of CC(US)

- Captured and liquified CO2 stored underground
- World's 1st: Boundary Dam, Saskatchewan
- Only half of 90% captured will reach storage
- Design issues = 40% operational time only
- Short on CO2 supply contract for Enhanced Oil Recovery (Cenovus)
- $21m penalties for SaskPower
- 30 year ROI revised forecast $240-270m lower

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5. More Difficult Challenges – History of CC(US)

- Most schemes focused on EOR (c.75%)
- Funding for CCS pilots cut – projects shelved
- E.g. White Rose @ Drax, North Yorkshire, UK
- UK Government pulled £1b funding in 2015
- Schwarze Pumpe (2006) shelved 2014 and sold (Vattenfall)
- Very high CAPEX and O&M – raising prices
- IEA CCC* Report Nov 2016 – "20 years of CCS"

(*Now the ICSC (International Centre for Sustainable Carbon) focused on biomass, coal and waste)

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6. Current/Planned R&D and Timelines

Carbon capture – Using Fluidic Oscillator Technology

Greenhouse Gas Exhaust Reclamation (GEGR)

- Uses an isothermal distillation process uses Desai-Zimmerman Fluidic oscillators (DZFO) that inject micro bubbles into a thin film of liquid that causes volatiles to evaporate in a non-equilibrium process that does not heat the liquid appreciably.
- Lab scale results indicate up to 94% CO_2 captured
- Next step is to incubate in a VCT, scale and commercialize

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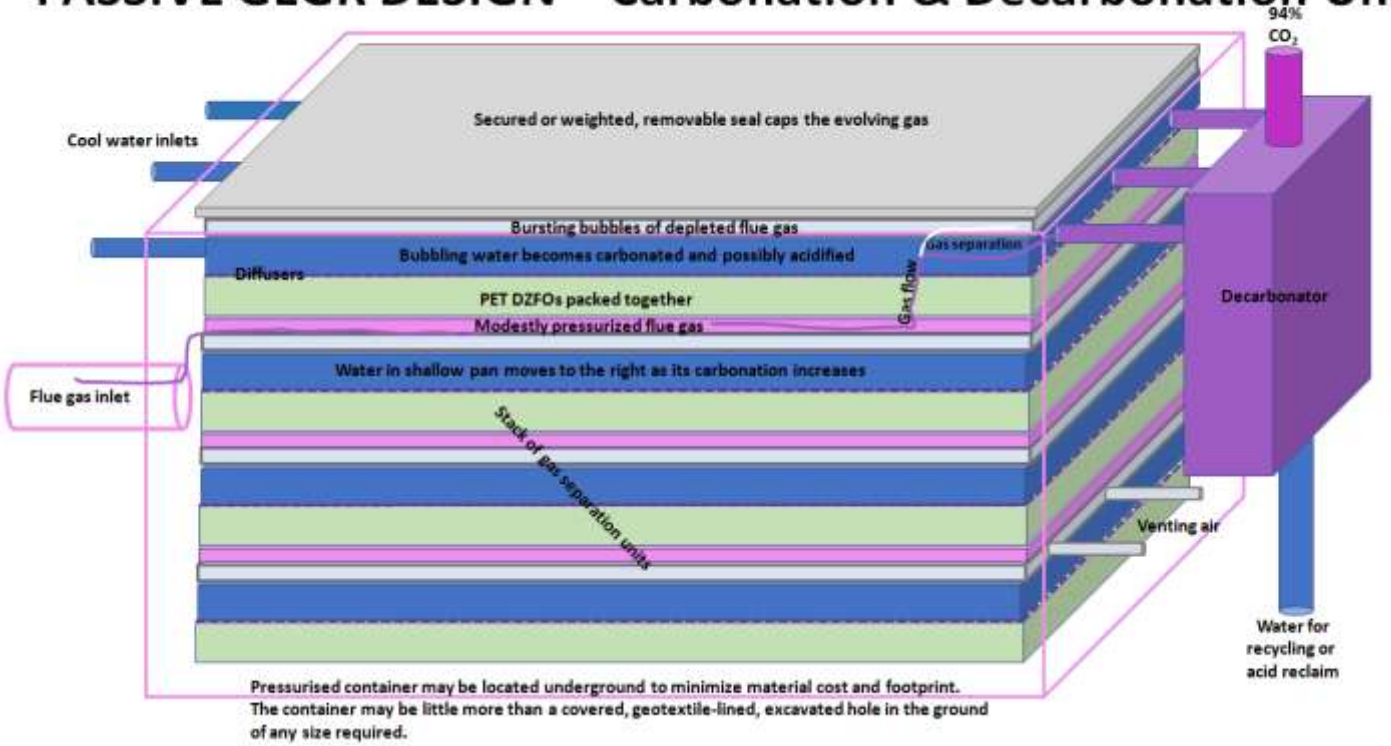
Current/Planned R&D and Timelines

Carbon capture using DZFO Technology for GEGR



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Conclusions 1

1. Greening of coal is not only possible but essential.
2. Decarbonisation is required throughout the supply chain
3. From mining, processing, combustion & circular economy
4. Attractive revenue share model essential to fund retrofits
5. With valuable extra Ag retrieval great profits possible
6. We want to attract HNWIs to fund coal's transition
7. We can help them leverage their returns to fund more

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FINAL Conclusions

1. Greening of coal: can we reach zero emission YES(almost)
2. Combining 40% coal activation savings and 94% fluidic oscillator carbon capture of the rest of gases = 96.4%.
3. What we need to do in parallel is to develop carbon utilisation pathways e.g. graphene extraction technology (stratographic graphene).
4. This will drive the scaling and commercialising of super/ultracapacitor energy storage.
5. This is the target.

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CARBON NEUTRAL COAL

(Well 96.4% anyway!)

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