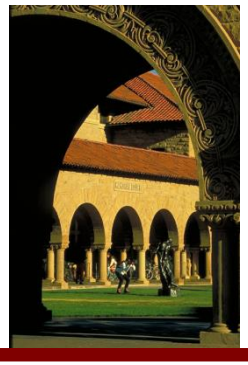

Instytut Polityki Energetycznej im. Ignacego Łukasiewicza
Politechnika Rzeszowska
Rzeszów, 24-25 kwietnia 2017 r.

II-ga Ogólnopolska Konferencja Naukowa

„Bezpieczeństwo energetyczne – filary i perspektywa rozwoju”

Piotr D. Moncarz, Ph.D., P.E., NAE
Adjunct Professor, Stanford University
Senior Fellow, Exponent
Przewodniczący, ElectroMobility Poland SA

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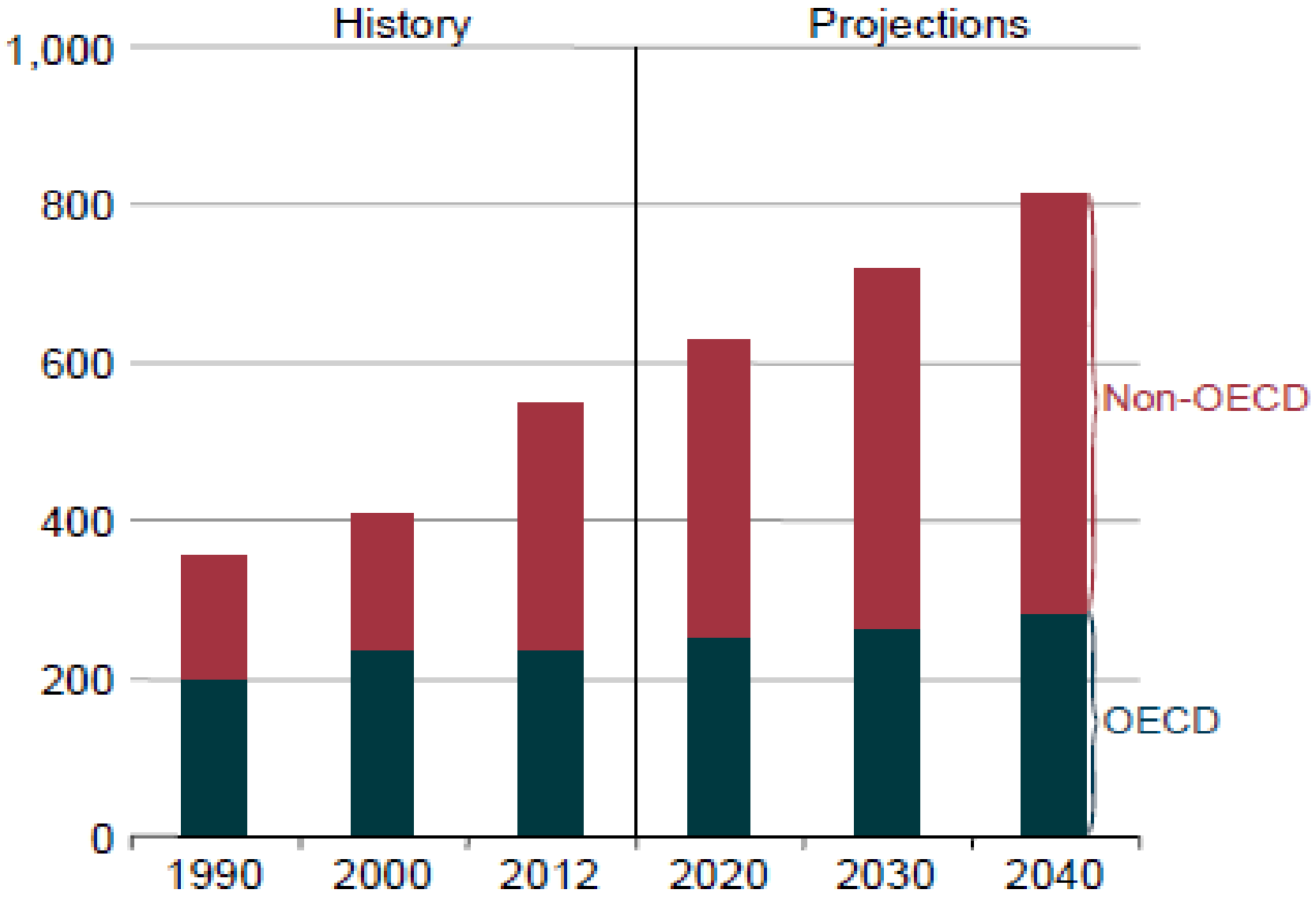
World energy consumption, 1990–2040



U.S. Energy Information Administration | International Energy Outlook 2016

World energy consumption by country grouping

2012–40 (quadrillion Btu)

Region	2012	2020	2025	2030	2035	2040	Average annual percent change, 2012-40
OECD	**238**	**254**	**261**	**267**	**274**	**282**	**0.6**
Americas	118	126	128	131	134	138	0.6
Europe	81	85	87	90	93	96	0.6
Asia	39	43	45	46	47	48	0.8
OECD with U.S. CPP	**238**	**252**	**258**	**265**	**272**	**280**	**0.6**
OECD Americas with U.S. CPP	118	124	125	128	132	136	0.5
Non-OECD	**311**	**375**	**413**	**451**	**491**	**533**	**1.9**
Europe/Eurasia	51	52	55	56	58	58	0.5
Asia	176	223	246	270	295	322	2.2
Middle East	32	41	45	51	57	62	2.4
Africa	22	26	30	34	38	44	2.6
Americas	31	33	37	40	43	47	1.5
Total World	**549**	**629**	**674**	**718**	**766**	**815**	**1.4**
Total World with U.S. CPP	**549**	**627**	**671**	**715**	**763**	**813**	**1.4**

U.S. Energy Information Administration | International Energy Outlook 2016

Źródła i nośniki	Przetwarzanie	Magazyno-wanie	Zużycie	Elektro-mobilność	Transport publiczny
Węgiel	Naziemne, podziemne (?)	Systemy szczytowo-pompowe	**Najtańszą energią jest energia nieużyta**	**Baterie**	Electro-busy itd.
Ropa/gaz	Spalanie, ogniwa, ...	Akumulatoty elektryczne		Elektro-mechanika	**Personal Rapid Transport**
radioaktywne	BWR,PWR, nowe generacje (?)	Mechaniczne (fly wheel, ciśnienie itp)	**Koszt**	informatyka	Hyperloop
Geo-ciepło	Geotermia mokra i sucha	Termalne	**Środowisko**	Infrastruktura	Bezp. i niezawodność
hydro	Zapory, micro-turbiny		**Klimat**	**Autonomia**	Sterowanie
wiatr	Rozproszone, farmy			**Cyber-security**	
słońce	Photo-voltaica, thermo-solar			Model własnościowy	

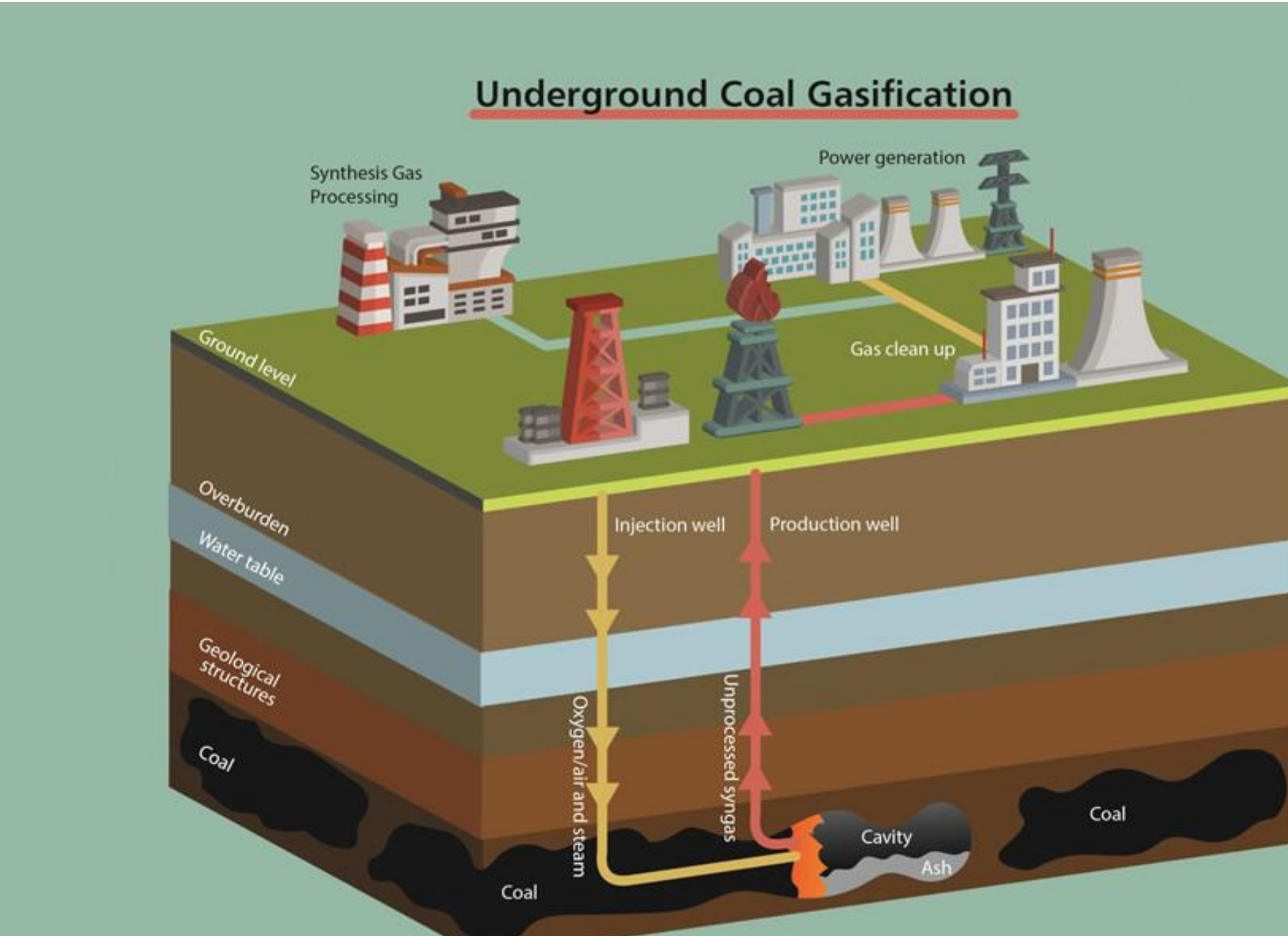
Coal

- Coal's share of global primary energy consumption fell to 29.2%, the lowest share since 2005.

Producers	Mt	% of world total
People's Rep. of China	3 527	45.8
United States	813	10.5
India	691	9.0
Australia	509	6.6
Indonesia	469	6.1
Russian Federation	349	4.5
South Africa	252	3.3
Germany	185	2.4
Poland	136	1.8
Kazakhstan	107	1.4
Rest of the world	671	8.6
World	**7 709**	**100.0**

2015 provisional data

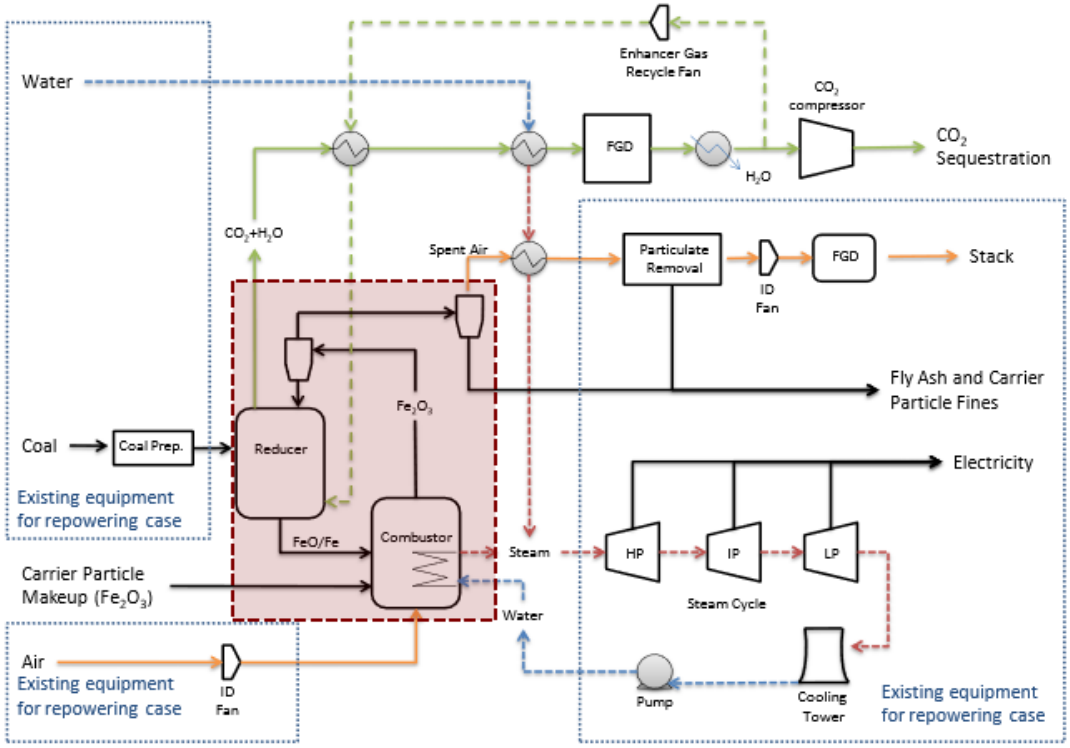
International Energy Agency
Secure Sustainable Together


Underground Coal Gasification
Synthesis Gas Processing
Power generation
Gas clean up
Ground level
Overburden
Water table
Geological structures
Coal
Injection well
Production well
Oxygen/air and steam
Unprocessed syngas
Cavity
Ash
Coal
Coal

Coal-Direct Chemical Looping (CDCL)

- Process using iron-based oxygen carriers has been developed as a coal conversion process with in situ CO2 capture.
- The CDCL system cycles oxygen carriers between two reactors, a reducer reactor and a combustor reactor, in order to convert coal for electric power generation.
- In development at Ohio State for a over decade and according to its inventor, L.S. Fan, its 5 or more years from commercialization.
- 25kw and 250kw pilots have been run successfully.
- Industry partners are Southern Company and Babcock and Wilcox.
- Majority of $6,500,000 funding provided by US Department of Energy.

Economics on Chemical Looping Process



	Base Plant	MEA Plant	CDCL Plant
First-Year Capital ($/MWh)	31.7	59.6	44.2
Fixed O&M ($/MWh)	8.0	13.0	9.6
Coal ($/MWh)	14.2	19.6	15.9
Variable O&M ($/MWh)	5.0	8.7	8.7
TOTAL FIRST-YEAR COE ($/MWh)	**58.9**	**100.9**	**78.4**

Δ = +71%

Δ = +33%

- Retrofit to conventional coal combustion process
- CDCL replaces existing PC boiler
  - Additional equipment for CO_2 compression and transportation required
- Techno-Economic analysis performed comparing CDCL to Base Plant with no CO_2 capture and 90% CO_2 capture via post-combustion MEA process

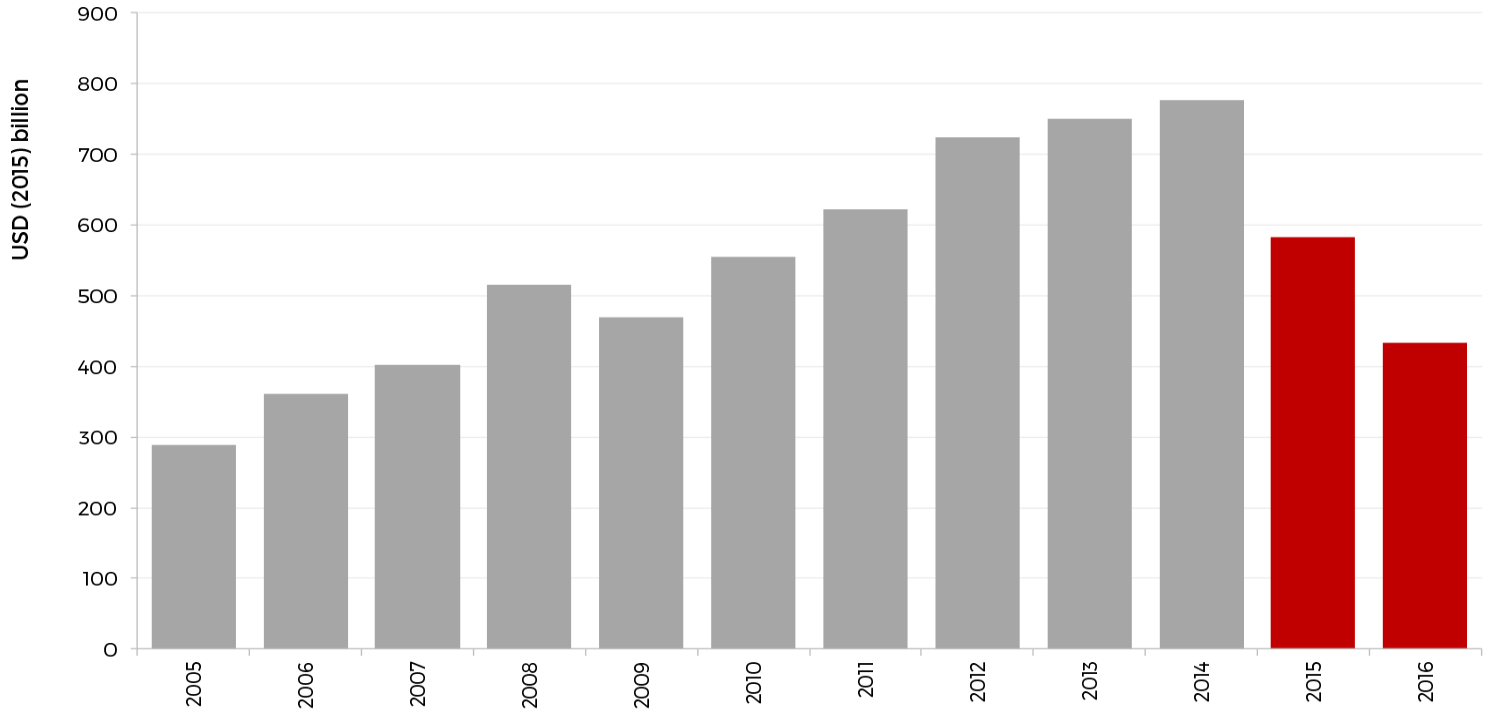
OIL AND GAS : Price and supply security vs. World political stability

(Photograph: Getty Images)

Cost of secure supplies

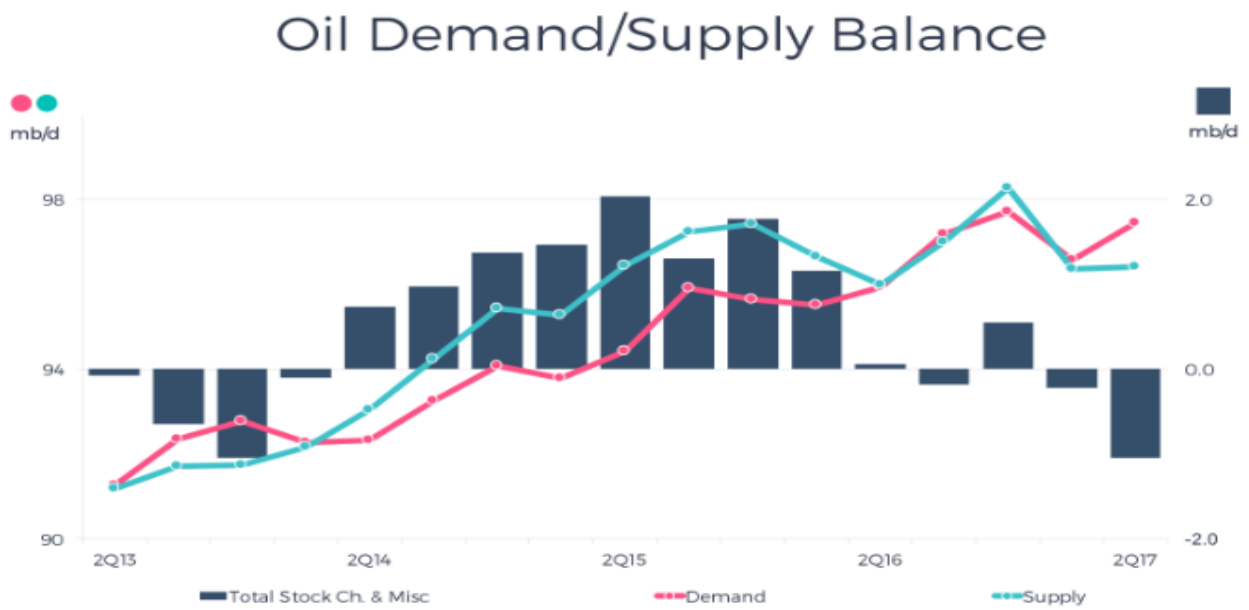
- In the first half of this decade, more capital was committed year after year to oil and gas upstream projects in the United States than in Russia and the Middle East combined.
- As a result of price-crisis in two years the US shale industry cut in half the development cost of shale project.
- The US shale industry came perilously close to losing access to capital. Major international oil companies borrowed over $100 billion in order to maintain dividend payments.

World upstream oil and gas investment



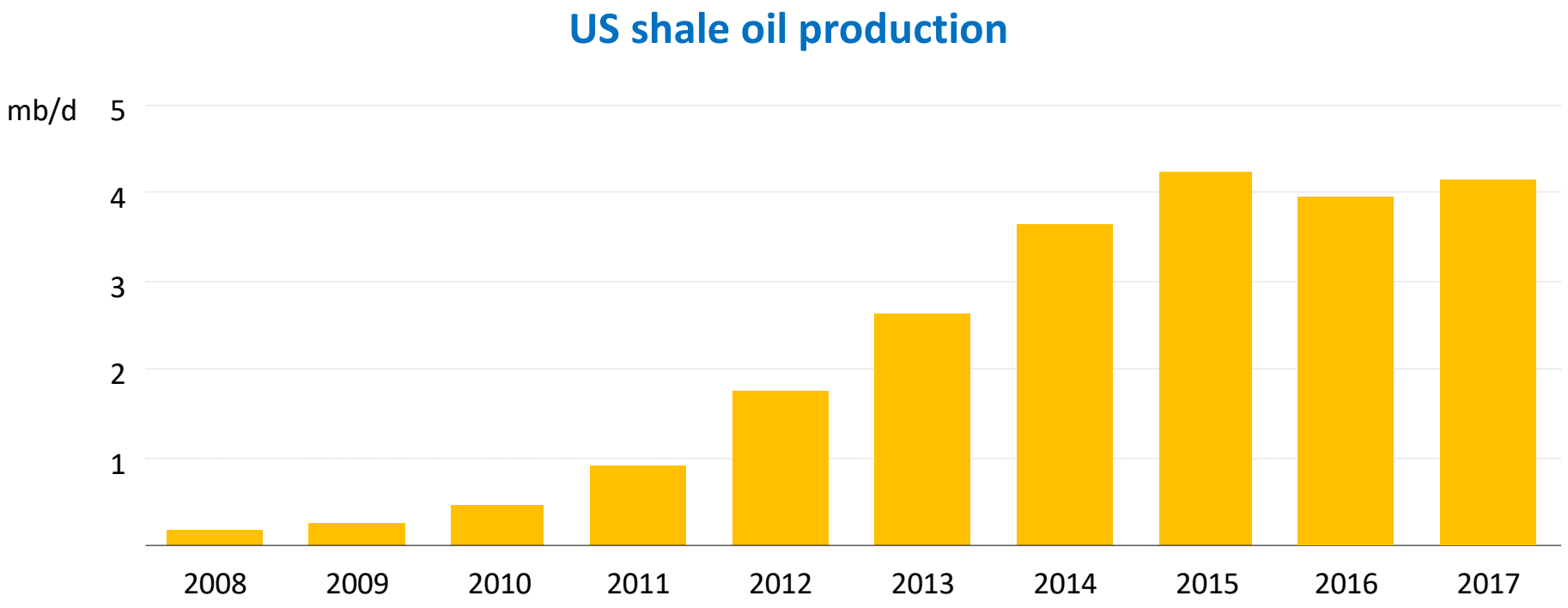
Reports of oil's death are premature.

- The IEA's *World Energy Outlook 2016* shows oil demand associated with passenger cars declining in the next 25 years.
- for now electric cars only displace 0.01% of global oil demand.



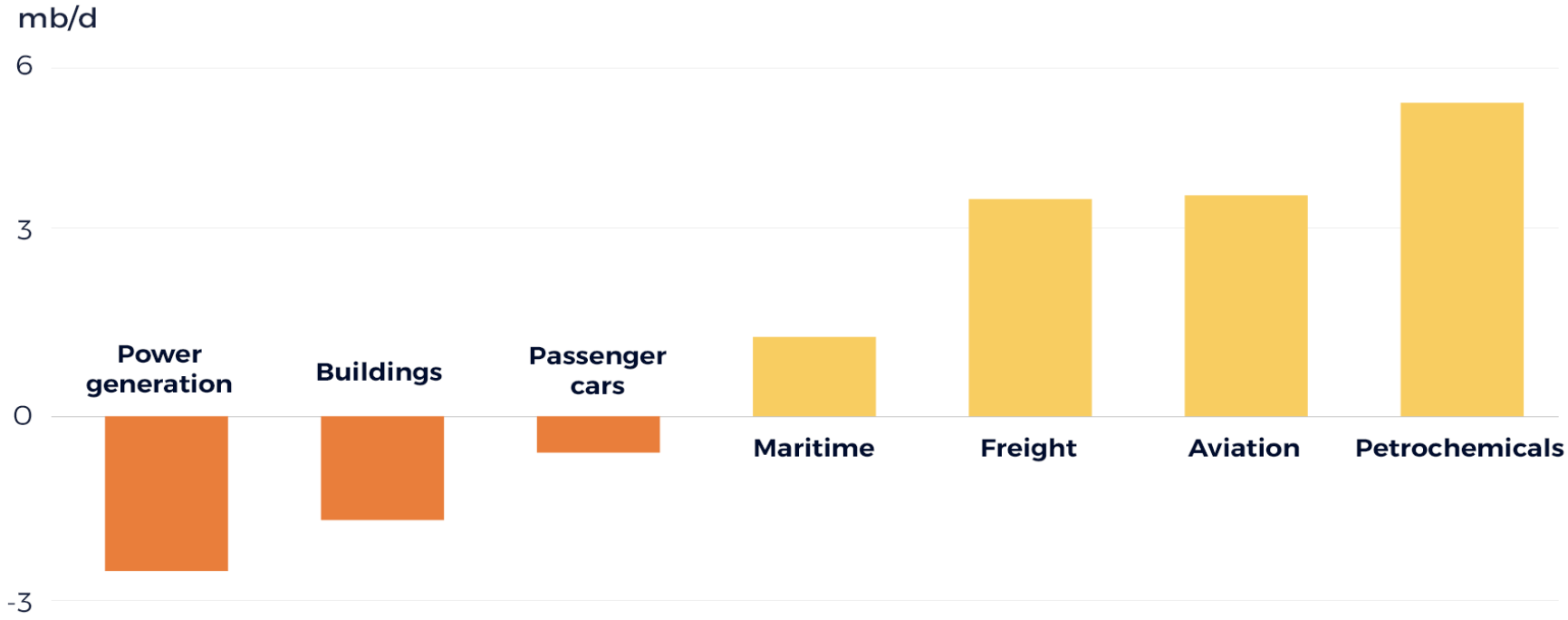
Note: For scenario purposes only, IEA assumes OPEC Production remains unchanged to end-2Q17

US shale oil has shaken up global oil markets…



US shale oil has surged in recent years and can continue to deliver impressive growth,

Change in oil demand by sector, 2015-2040



Renewables

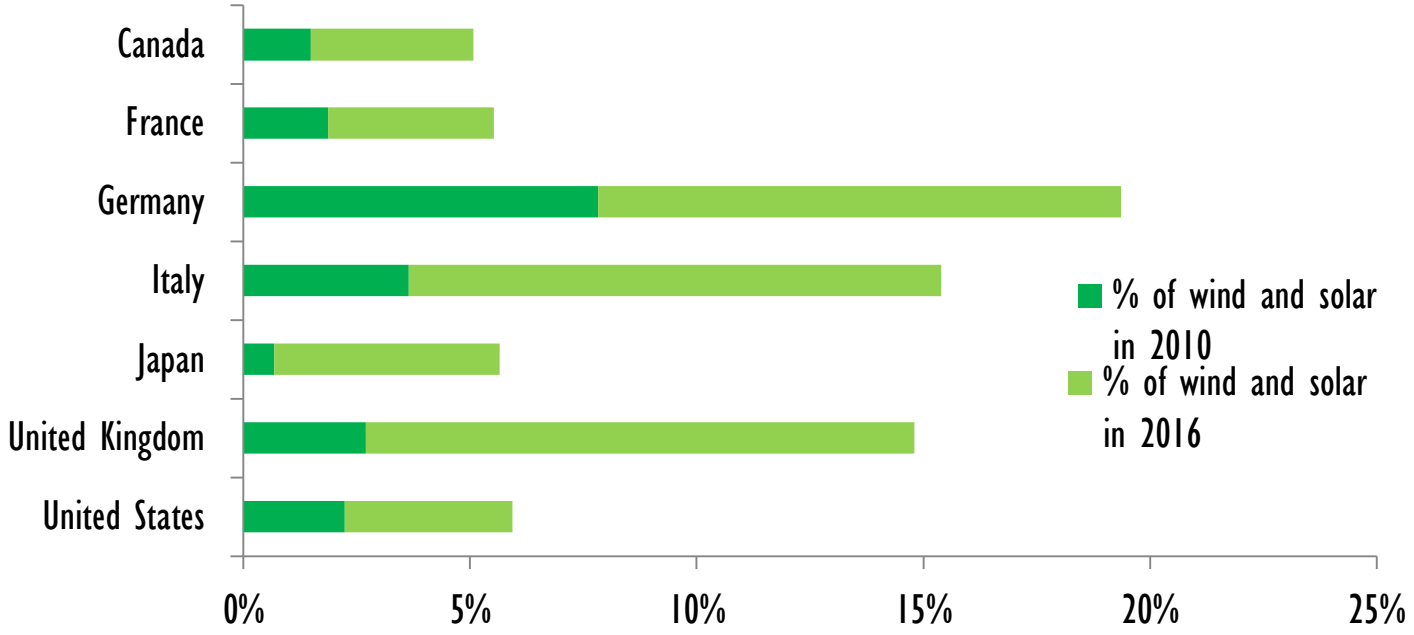
- Renewable energy sources in power generation continued to increase in 2015, reaching 2.8% of global energy consumption, up from 0.8% a decade ago.

- Renewable energy used in power generation grew by 15.2%, slightly below the 10-year average growth of 15.9% but a record increment (+213 terawatt-hours), which was roughly equal to all of the increase in global power generation.

- Renewables accounted for 6.7% of global power generation.

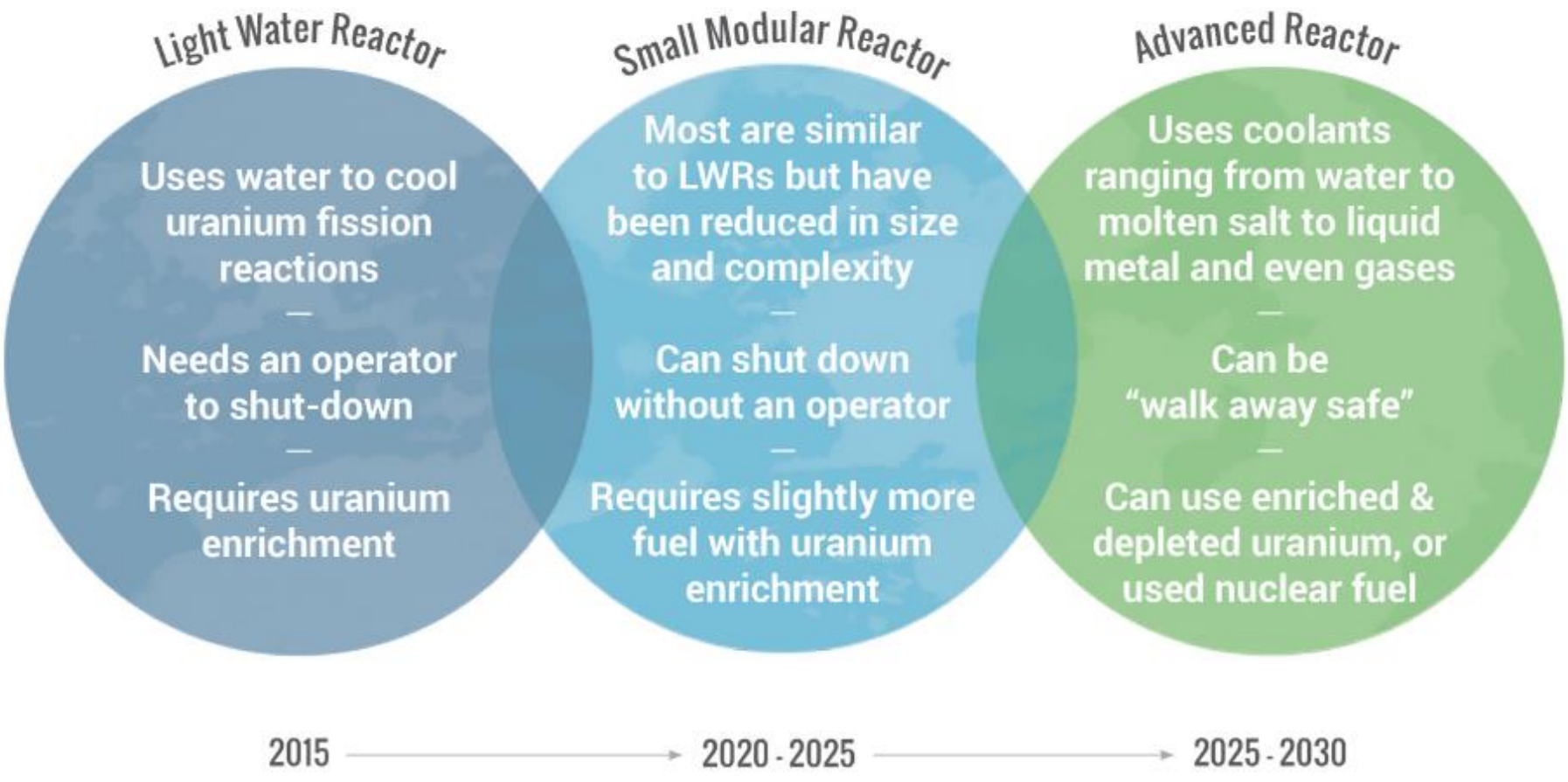
Renewables are growing throughout the G7, but new challenges are emerging

Share of wind and solar in total electricity generation



Better grids, more flexible power plants and storage & demand side response will be needed to integrate larger shares of wind & solar in a secure and cost-effective way

Nuclear's Continuing Evolution



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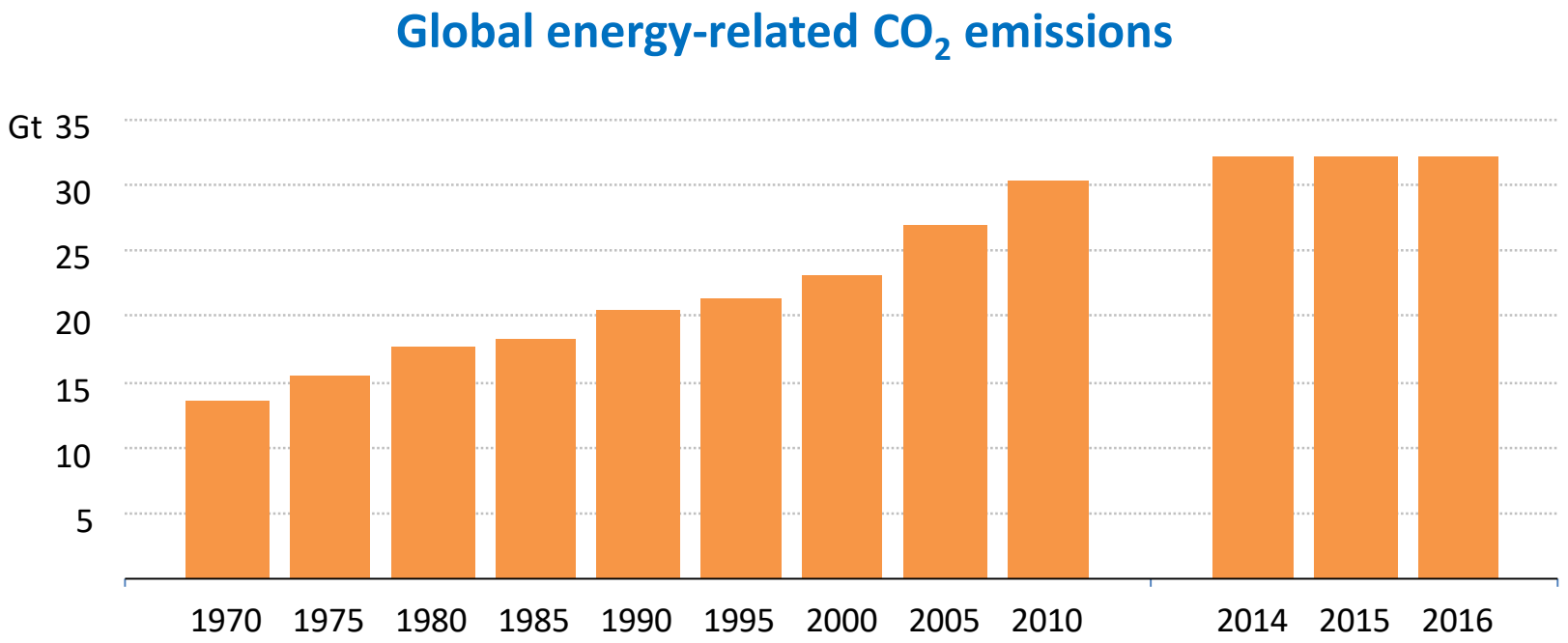
third way

Global CO_2 emissions flat for 3 years – an emerging trend?



IEA analysis shows that global CO2 emissions remained flat in 2016 for the third year in a row, even though the global economy grew, led by emission declines in the US & China

Security: Physical and Cyber Attack

BP report

Energy Storage

- Solid State Batteries
- Flow Batteries
- Flywheels
- Compressed Air Storage
- Thermal Pumped Storage

Energy storage is expanding rapidly

- NEC Energy Solutions is supplying a 48MW / 50MWh lithium-ion battery system for Dutch energy supplier Eneco and Japanese conglomerate Mitsubishi Corporation in Jardelund, Germany. It's expected to be operational by years end.

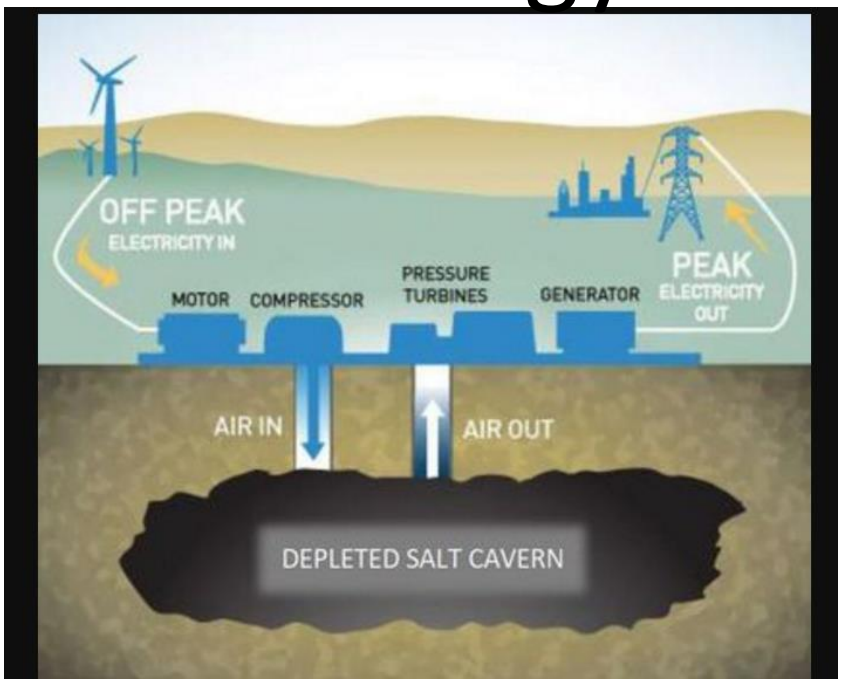
- In Northern Ireland Gaelectric, with technology partner, Dresser-Rand, is building a 300MW CAES system capable of providing power for up to 6 hours. It's been granted 90 million euros by the EU. Completion is expected in 2022.

- The UK government thru its 'Faraday Challenge' has committed almost €250m over four years for R&D in energy storage and batteries for electric vehicles.

- UK Construction company Anesco is collaborating with UK electric utility company Limejump to bring 185MW of energy storage online by the end of next year.

- **The State of California is mandating that its major utilities have 1.325 GW of storage by 2020. 221 MW was installed in 2016**

Compressed Air Energy Storage (CAES)



- Fortune 500 engineering firm AECOM acting as project developer partner and providing cost and performance guarantees
- Canadian financial firm Canoe Financial has committed to project financing. Key bankability metrics in place.
- Estimates for 200 MW or more $150 / kWhr for 6 to 8 hours compared to $550 / kWhr for 4-hour utility-scale battery systems

mage: Hydrosor

©Heliphoto.net

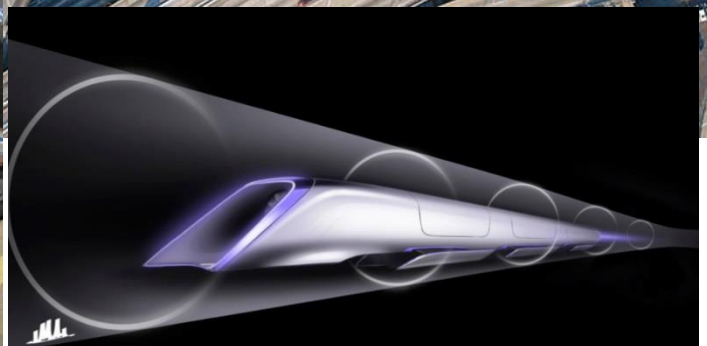
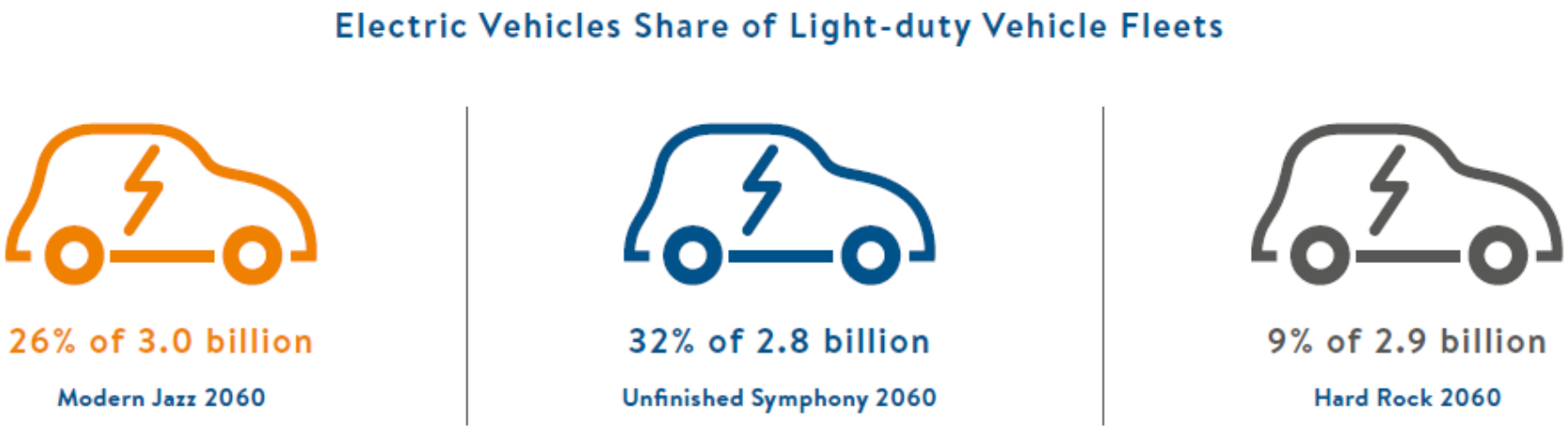
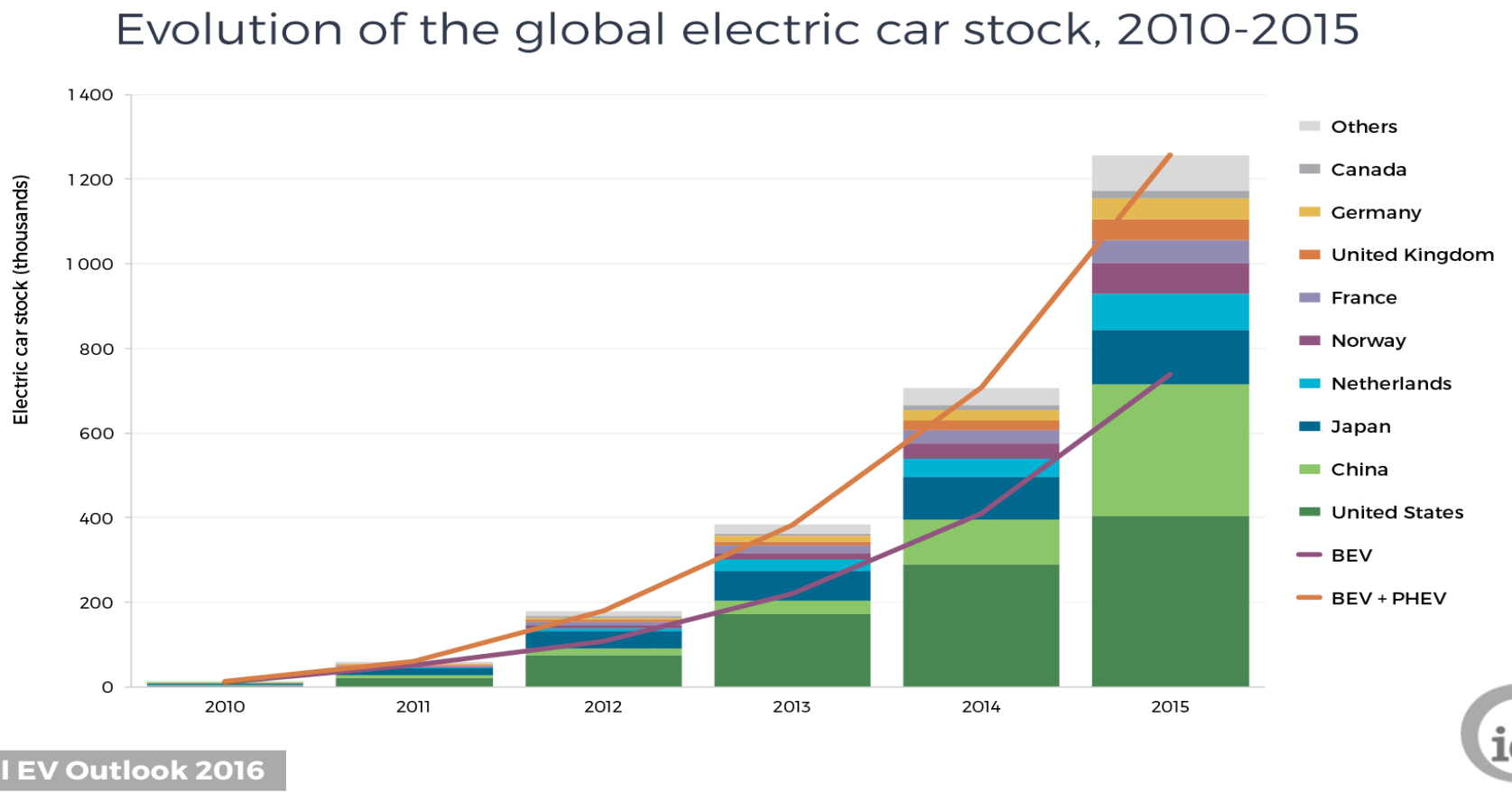


FIGURE 9: THE ANTICIPATED RAPID PENETRATION OF ELECTRIC VEHICLES



Source: World Energy Council, Paul Scherrer Institute, Accenture Strategy



Forecasting of electric vehicles on the road by 2020[31] :

- OPEC 1.7 million
- BNEF 7.4 million.[32]

Challenges: battery price and charging infrastructure

Exponent®

Exploring the Evolving Automated Vehicle Landscape

Ryan Harrington

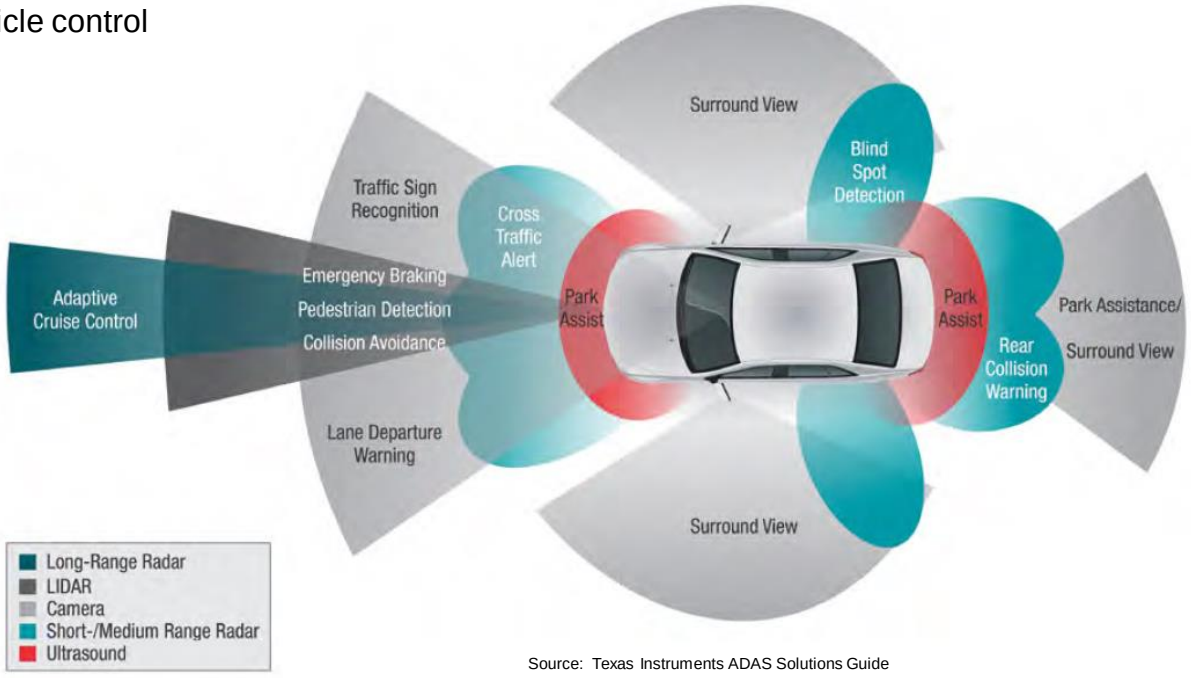
Presentation Outline

- Automated Vehicle (AV) Development
- Federal and State Activities
- The Future of Automated Vehicles

Automated Vehicle Development

Automated Vehicle (AV) Technology

- Progression of Advanced Driver Assistance Systems (ADAS) to automation
- Sensor fusion integrated into vehicle control
- Vehicle connectivity
- Human machine interface (HMI)



Source: Texas Instruments ADAS Solutions Guide

Levels of Automation – SAE International J3016 Definitions

SAE Level	Name	Narrative Definition	Execution of Steering/ Acceleration/ Deceleration	*Monitoring* of Driving Environment	Fallback Performance of *Dynamic Driving Task*	System Capability (*Driving Modes*)
Human driver monitors the driving environment						
0	No Automation	the full-time performance by the *human driver* of all aspects of the *dynamic driving task*, even when enhanced by warning or intervention systems	Human driver	Human driver	Human driver	n/a
1	Driver Assistance	the *driving mode*-specific execution by a driver assistance system of either steering or acceleration/deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	Human driver and system	Human driver	Human driver	Some driving modes
2	Partial Automation	the *driving mode*-specific execution by one or more driver assistance systems of both steering and acceleration/deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	**System**	Human driver	Human driver	Some driving modes
Automated driving system ("system") monitors the driving environment						
3	Conditional Automation	the *driving mode*-specific performance by an *automated driving system* of all aspects of the *dynamic driving task* with the expectation that the *human driver* will respond appropriately to a *request to intervene*	System	**System**	Human driver	Some driving modes
4	High Automation	the *driving mode*-specific performance by an *automated driving system* of all aspects of the *dynamic driving task*, even if a *human driver* does not respond appropriately to a *request to intervene*	System	System	**System**	Some driving modes
5	Full Automation	the full-time performance by an *automated driving system* of all aspects of the *dynamic driving task* under all roadway and environmental conditions that can be managed by a *human driver*	System	System	System	**All driving modes**

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Automation on Our Roads Today

https://www.google.com/selfdrivingcar/
http://www.wired.com/2015/10/tesla-self-driving-over-air-update-live/
http://www.motortrend.com/news/video-2014-mercedes-benz-s-class-demonstrates-features376363/
https://newsroom.uber.com/us-pennsylvania/new-wheels/

Federal and State Activities

Review of FMVSS for Automated Vehicles

- Sought to identify potential barriers and challenges for the certification of automated vehicles using existing Federal Motor Vehicle Safety Standards (FMVSS).
  - To ensure existing regulations do not unduly stifle innovation and;
  - To help ensure automated vehicles perform their function safely.
- The review revealed for conventional vehicles that there are few barriers for automated vehicles to comply with FMVSS.
- Automated vehicles that begin to push the boundaries (*e.g.*, alternative cabin layouts, omission of manual controls) would be constrained by the current FMVSS.

Federal Automated Vehicles Policy (FAVP)

Main Sections

- Vehicle Performance Guidance for Automated Vehicles
- Model State Policy
- NHTSA's Current Regulatory Tools
- New Tools and Authorities

Levels of Automation

- Adopts SAE International definitions (SAE J3016)

Applicability

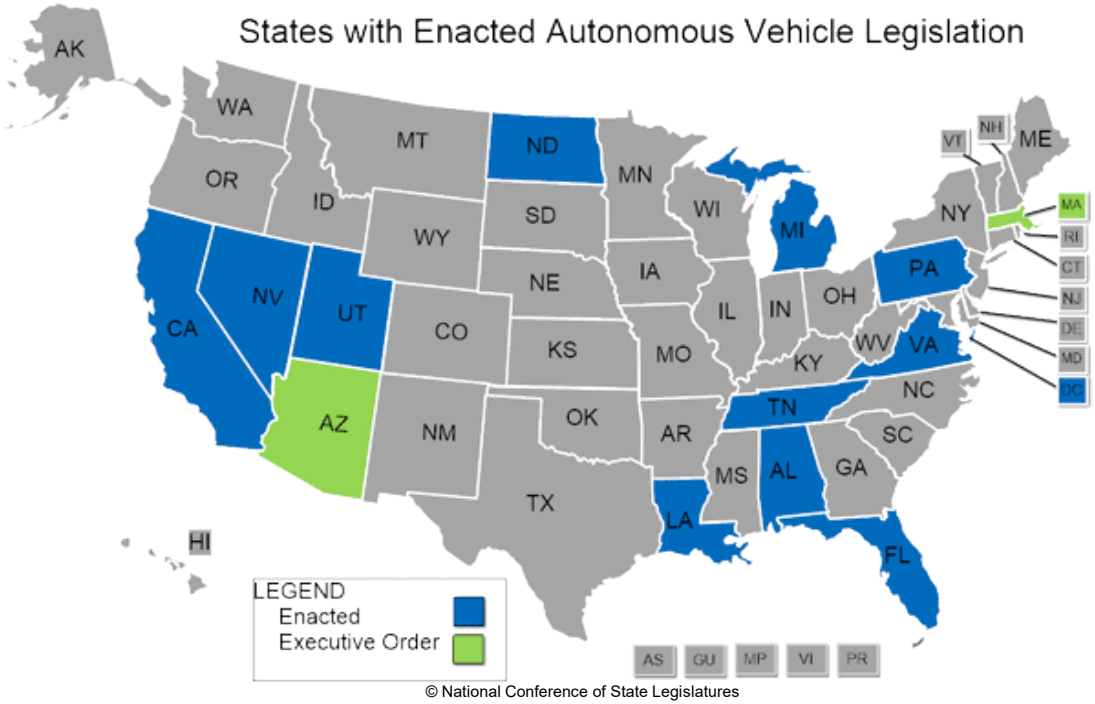
- ...all individuals and companies manufacturing, designing, testing, and/or planning to sell automated vehicle systems in the United States
- …all classes of motor vehicles, including passenger cars, trucks, and buses

Vehicle Performance Guidance – 15 Point Safety Assessment

- Data Recording and Sharing
- Privacy
- System Safety
- Vehicle Cybersecurity
- Human Machine Interface
- Crashworthiness
- Consumer Education and Training
- Registration and Certification
- Post-Crash Behavior
- Federal, State and Local Laws
- Ethical Considerations
- Operational Design Domain
- Object and Event Detection and Response
- Fall Back (Minimal Risk Condition)
- Validation Methods

Legislative Activity at the State Level

- Eleven states have passed automated vehicle legislation
- Two states have issued executive orders related to automated vehicles
- Michigan passed legislation on December 9, 2016
- California DMV issued proposed regulations on March 10, 2017



© National Conference of State Legislatures

Automation and the Transportation System

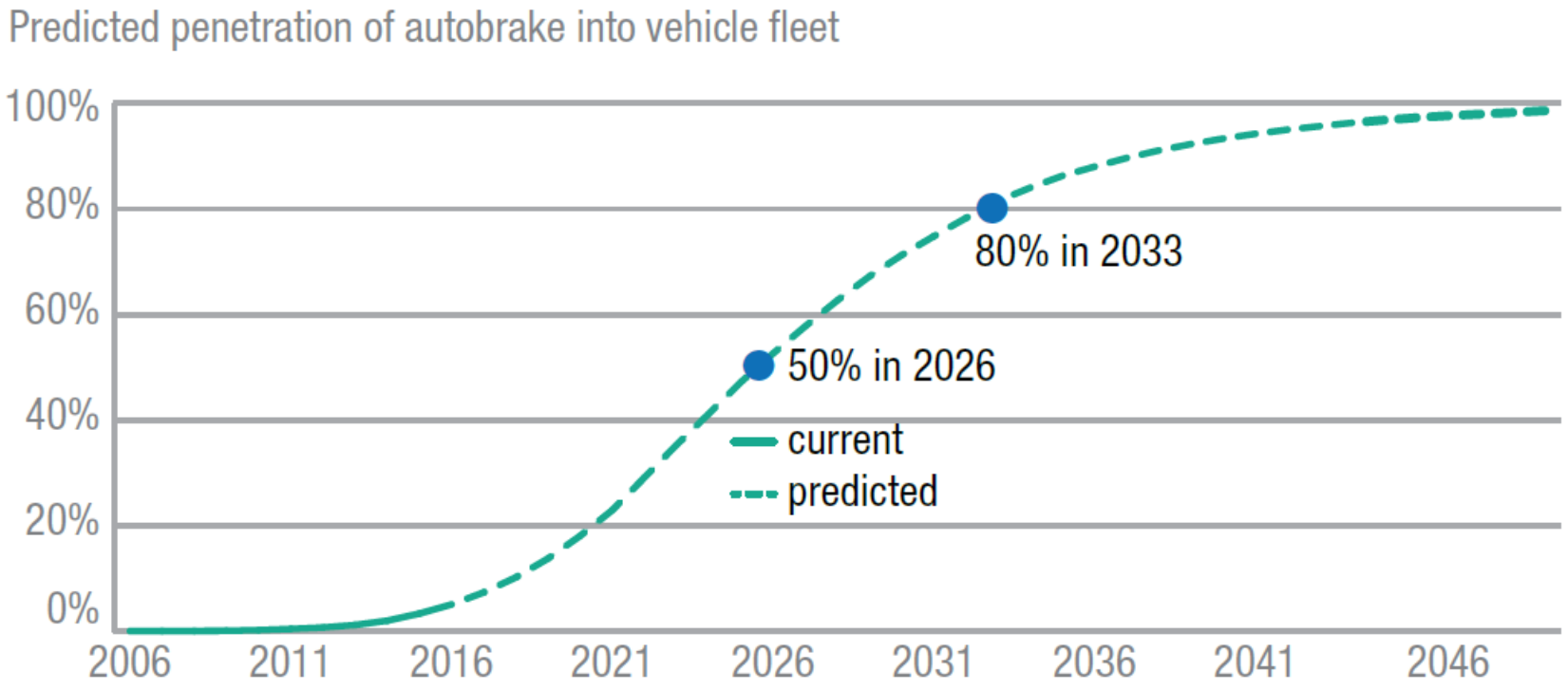
Key considerations:

- Multi-modal in nature:
  - Private passenger vehicles
  - Commercial vehicles
  - Transit operations
  - Ground drones
- Network efficiency of mixed fleet operation
- Shared vehicle ownership models
- Impact on vehicle miles traveled (VMT)
- Parking needs and design
- City layouts and land use

Unprecedented coordination between:

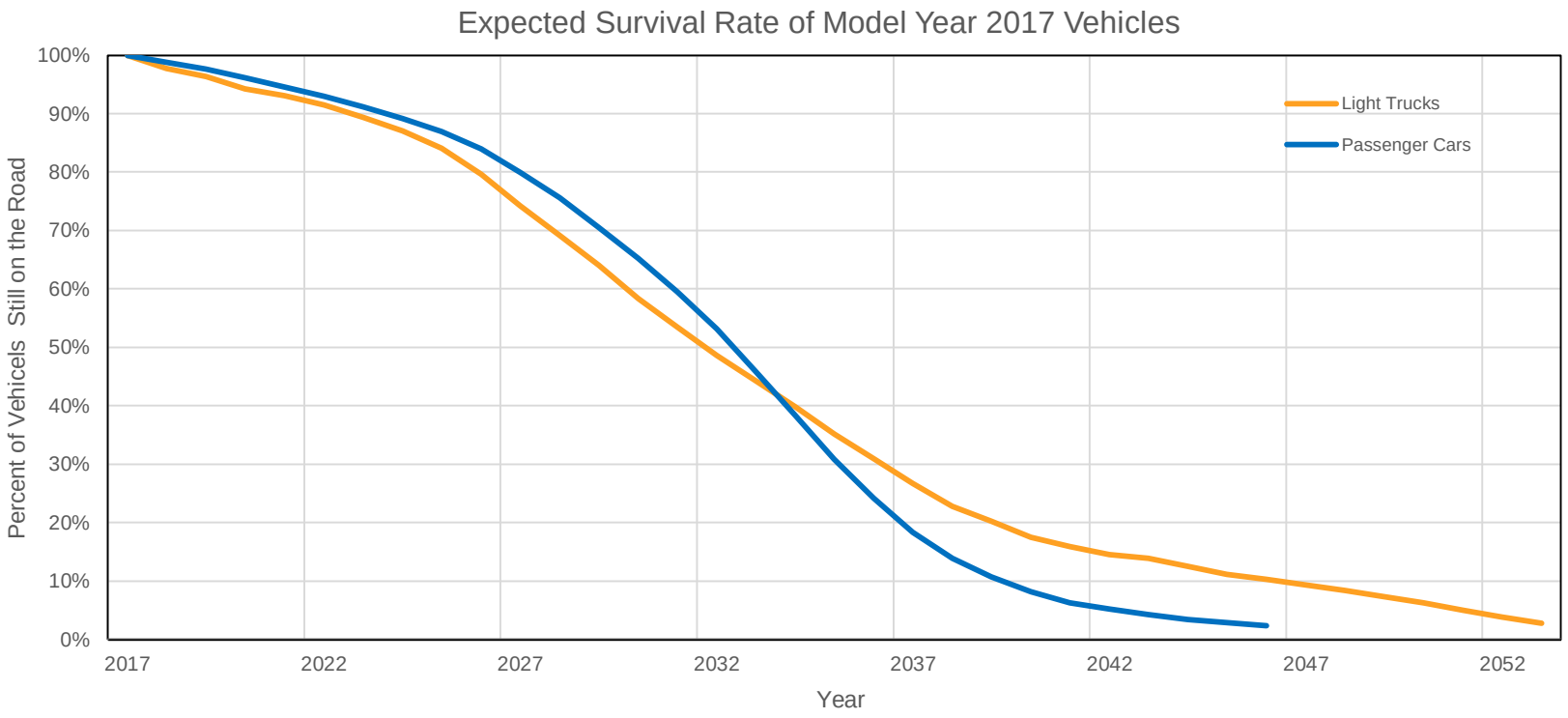
- Vehicle manufacturers
- Technology companies
- Component suppliers
- Transportation-as-a-service (TaaS) providers
- Industry groups
- Road owner / Operators
- Risk managers / Insurers
- Legal department
- Federal, state and local governments

Technology Deployment Rates



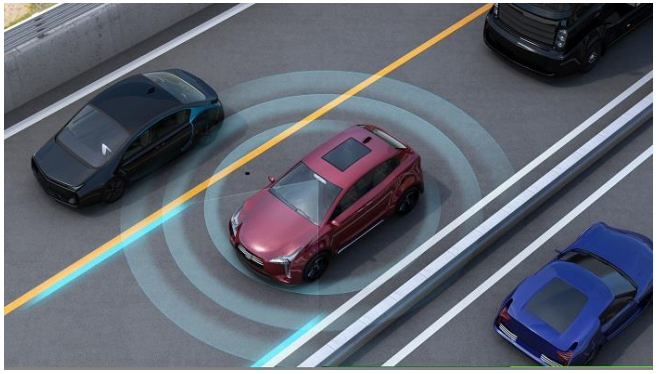
Source: Insurance Institute for Highway Safety, Arlington, Virginia USA. www.iihs.org.

Fleet Turnover Based on Expected Survival Rates



Data Source: Final Regulatory Impact Analysis – Corporate Average Fuel Economy for MY 2017-2025 Passenger Cars and Light Trucks. Office of Regulatory Analysis and Evaluation, National Center fro Statistics and Analysis, NHTSA. August 2012.

Safety Benefits



NHTSA statistics:

- 94% of crashes due to driver error
- 35,092 fatalities in 2015
- 10.4% increase in fatalities for first half of 2016 (early estimate)

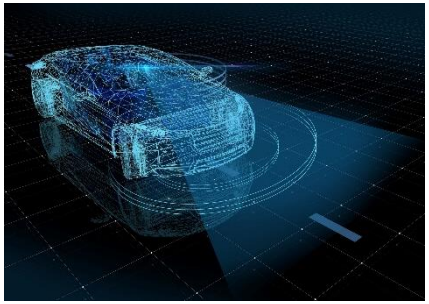
Safety Benefits Considerations:

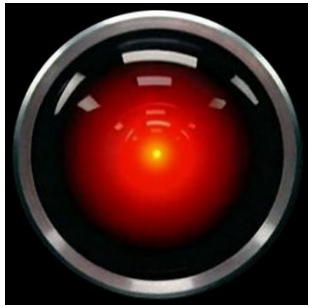
- Impact of potential VMT changes?
- How safe is safe enough?
- How to determine baseline with evolving performance and capabilities due to OTA updates?
- How to measure/consider crashes avoided?
- Alternative cabin layout crashworthiness testing?

Source: http://www.rinspeed.eu/

Litigation (and other) Considerations

- Data
- Machine learning and artificial intelligence (AI)
- Verification and validation testing
- Human machine interface (HMI)
- Shared vehicle ownership
- Annual inspections and repairs





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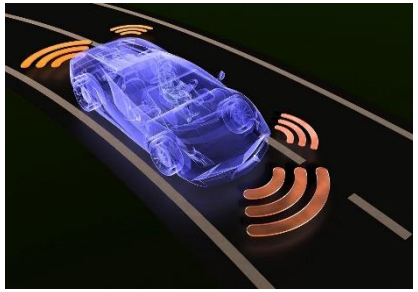

Thank you!

Ryan Harrington
Principal
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508-652-8543

Exponent Test & Engineering Center – Phoenix, AZ

ElectroMobility Poland SA

Budowa spójnego ekosystemu elektromobilności w Polsce

z szerokim wykorzystaniem polskich zasobów

Electromobilność Polski
Jaki model, jaka strategia?

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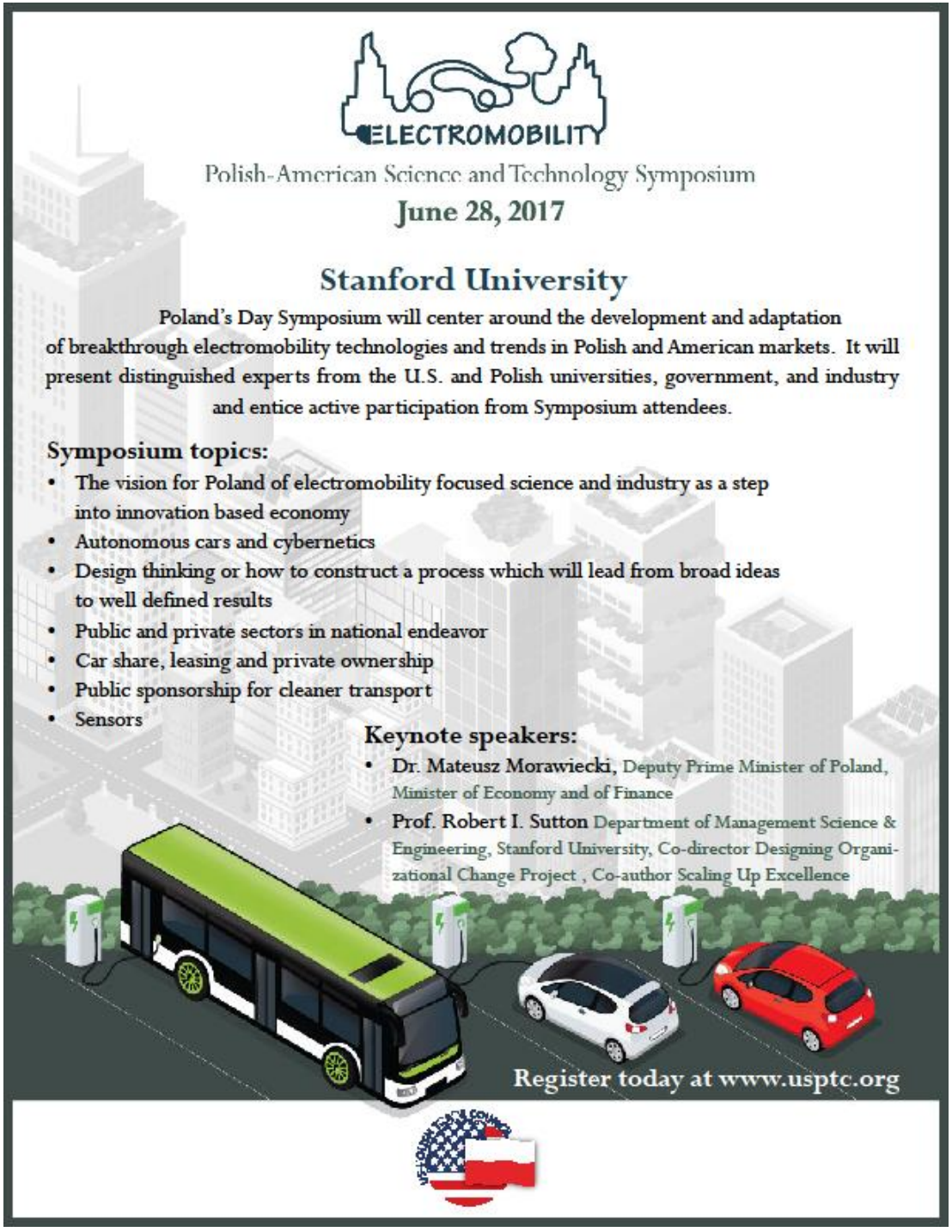
zapraszamy


ELECTROMOBILITY
Polish-American Science and Technology Symposium
June 28, 2017
Stanford University
Poland's Day Symposium will center around the development and adaptation of breakthrough electromobility technologies and trends in Polish and American markets. It will present distinguished experts from the U.S. and Polish universities, government, and industry and entice active participation from Symposium attendees.
Symposium topics:
• The vision for Poland of electromobility focused science and industry as a step into innovation based economy
• Autonomous cars and cybernetics
• Design thinking or how to construct a process which will lead from broad ideas to well defined results
• Public and private sectors in national endeavor
• Car share, leasing and private ownership
• Public sponsorship for cleaner transport
• Sensors
Keynote speakers:
• Dr. Mateusz Morawiecki, Deputy Prime Minister of Poland, Minister of Economy and of Finance
• Prof. Robert I. Sutton Department of Management Science & Engineering, Stanford University, Co-director Designing Organizational Change Project , Co-author Scaling Up Excellence
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Polish-American Science and Technology Symposium

June 28, 2017

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Poland's Day Symposium will center around the development and adaptation of breakthrough electromobility technologies and trends in Polish and American markets. It will present distinguished experts from the U.S. and Polish universities, government, and industry and entice active participation from Symposium attendees.

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- Public and private sectors in national endeavor
- Car share, leasing and private ownership
- Public sponsorship for cleaner transport
- Sensors

Keynote speakers:

"Silicon Valley" – ???

- Not a "Physical Place" – but a "MINDSET"
- Not "Decreed" – but conducive conditions "CREATED" from bottom-up
- Not just Triple Helix of "University-Industry-Government," – but multitude of diverse players
- **A "Free Market" of "Risk-Takers" seeking rewards**

Adapting Silicon Valley Concepts to Local Objectives, Needs and Conditions Is a "Process"

Source: Skrobiszewski, Moncarz

Stanford University

Global Project

Global, Multidisciplinary Team

Dziękuję za uwagę!

Życzę powodzenia w przygotowaniach do budowy bezpieczeństwa energetycznego i transportu XXI-go i XXII-go wieku

Please stay in touch

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