

# **Global Energy Transitions:**

## **The Role of Innovation in Shaping Future Energy Markets\***

**John A. “Skip” Laitner**  
**“Reframing” Energy for the 21st Century**

***A Conversation with Colleagues at the Gaidar Forum***

**Moscow, Russia**  
**January 14, 2016**

\* In the spirit and tradition of Nobel Laureate and former Caltech physicist Richard Feynman, in his 1959 visionary talk, “There’s Plenty of Room at the Bottom.” See, <http://www.its.caltech.edu/~feynman/plenty.html>.

# The Sustainability Elephant in the Room



Both are driven by the inefficient use of resources—materials, water, and especially energy...

Economic and Human Dimensions Research Associates ...

# A Five-Step Thought Experiment

- Explore the work underway for what we call the Deep Decarbonization Pathways Project (DDPP).
- Examine the critical difference between energy as a “commodity” versus energy as “work.”
- Review the scales of global energy transitions.
- Discuss the critical role of innovation in solving both the climate and the economic problem.
- Offer a final thought with suggested next steps ahead.

# Deep Decarbonization Pathways for Russia and the World



“The **Deep Decarbonization Pathways Project (DDPP)** is a 16 country **collaborative initiative** to understand and show how individual countries can transition to a low-carbon economy ...

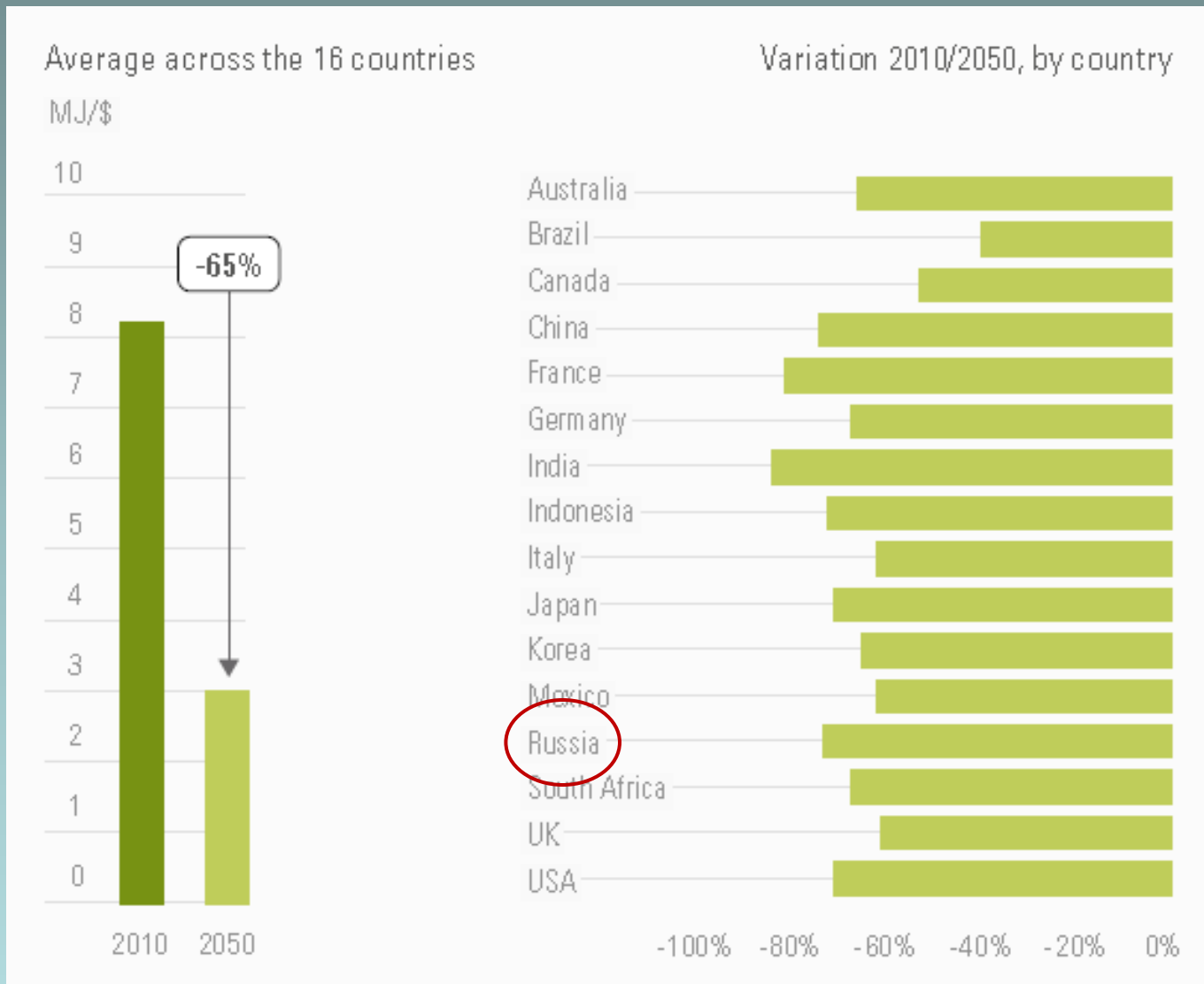
... limiting the increase in global mean surface temperature to less than **2 degrees Celsius (° C)**.

Achieving the 2° C limit will require that global net emissions of greenhouse gases (**GHG**) **approach zero** by the second half of the century.

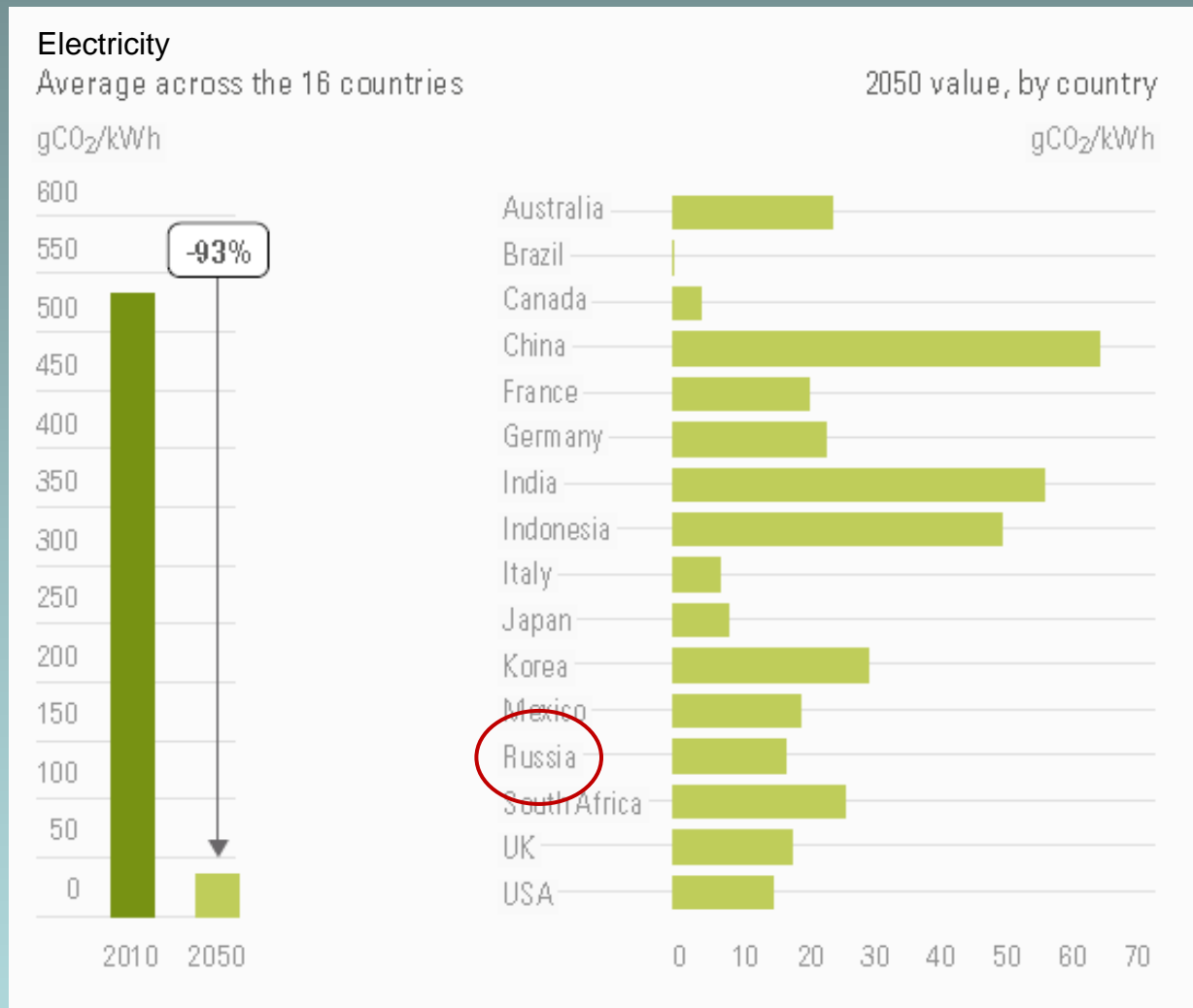
This will require a profound **transformation of energy systems ...** we call “**deep decarbonization.**”

<http://deepdecarbonization.org/>

# Deep Decarbonization Pathways: Changes in Energy Intensities



# Deep Decarbonization Pathways: Changes in Carbon Intensities



# GDP per Unit of Energy Use: Russia at 112 of 140 Countries



The Global innovation index 2014? <http://www.globalinnovationindex.org/content.aspx?page=data-analysis>

# And with Two Views on Energy

- **Typical:** Energy as *commodities* that are sold on the market (e.g., barrels of oil or kilowatt-hours of electricity) – tracked by the various governmental agencies.
- **More Vital:** Energy as the capacity to do useful *work*, necessary to transform matter into the requisite goods and services for a local economy, and to distribute or make them available as required.
- **Result:** To ensure the appropriate development of innovation that ensures sustainable economic activity, the *emphasis needs to be on energy as work*.



# Exploring Energy as Work

$$\text{Energy} = \text{Exergy} + \text{Anergy} = \text{Constant}$$

Source: Kümmel (2011)

$$\text{Work} = \text{Exergy} * \text{Efficiency}$$

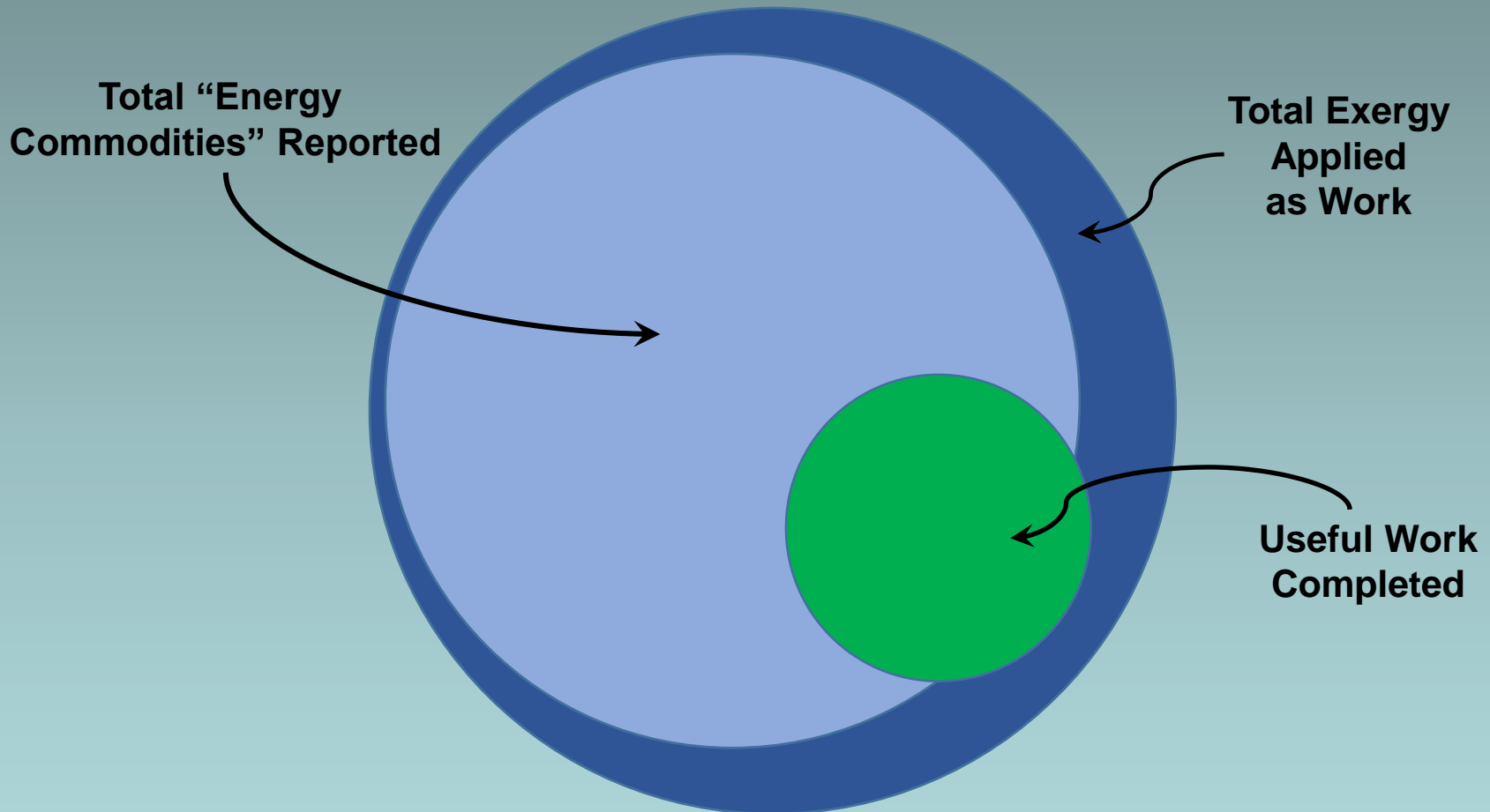
Source: Ayres and Warr (2009), and Laitner (2014, 2015)

$$\text{Waste} = \text{Exergy} * (1 - \text{Efficiency})$$

Source: By definition

Where “Exergy” is the total high quality energy available to transform matter into the desired mix of goods and services within a given economy.

# Comparing reported energy, applied exergy, and useful work



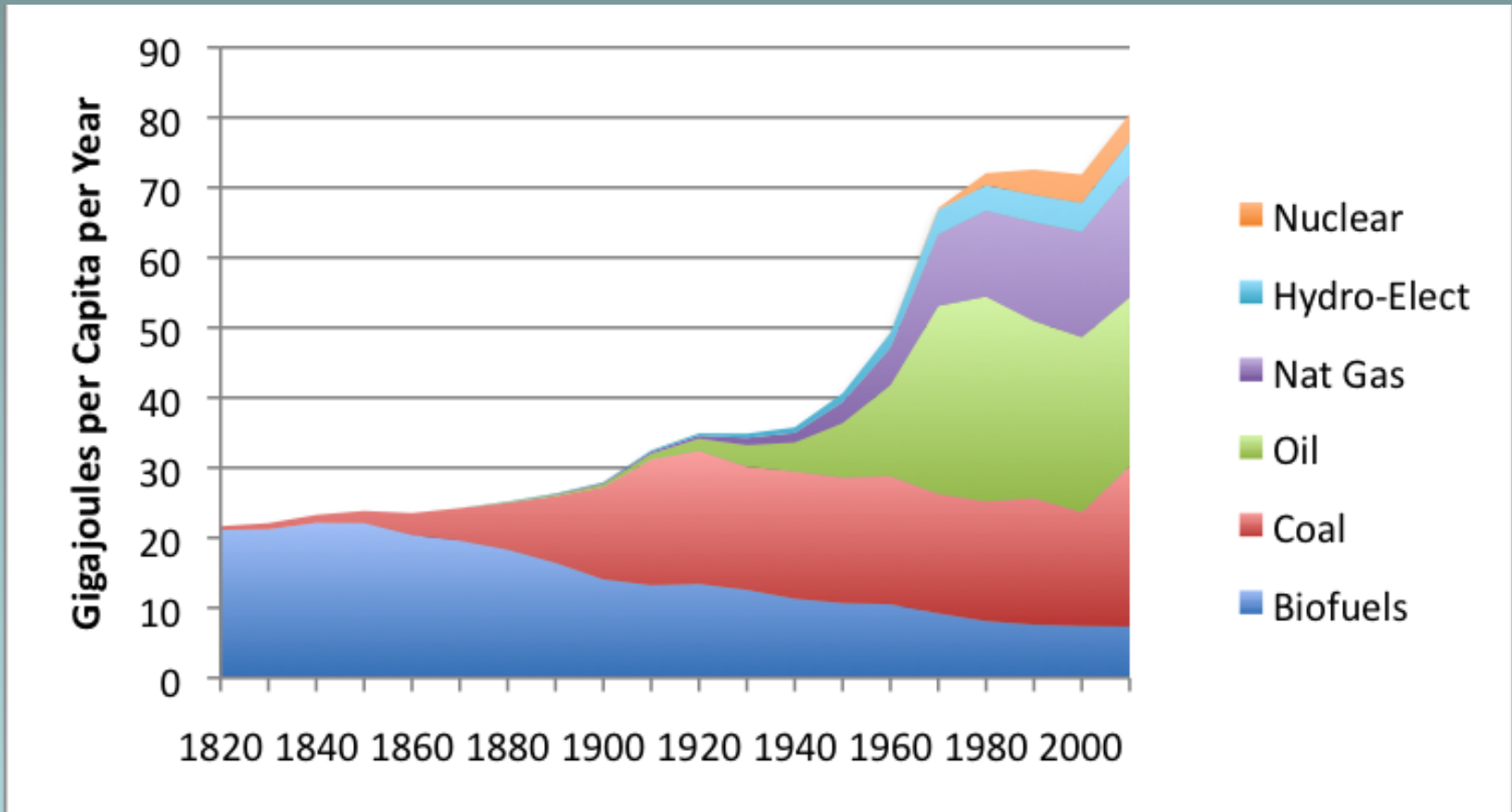
Where the difference between the useful work that is completed, and the total exergy that is consumed, amounts to waste or anergy. . .

# Energy Statistics for Key World Regions

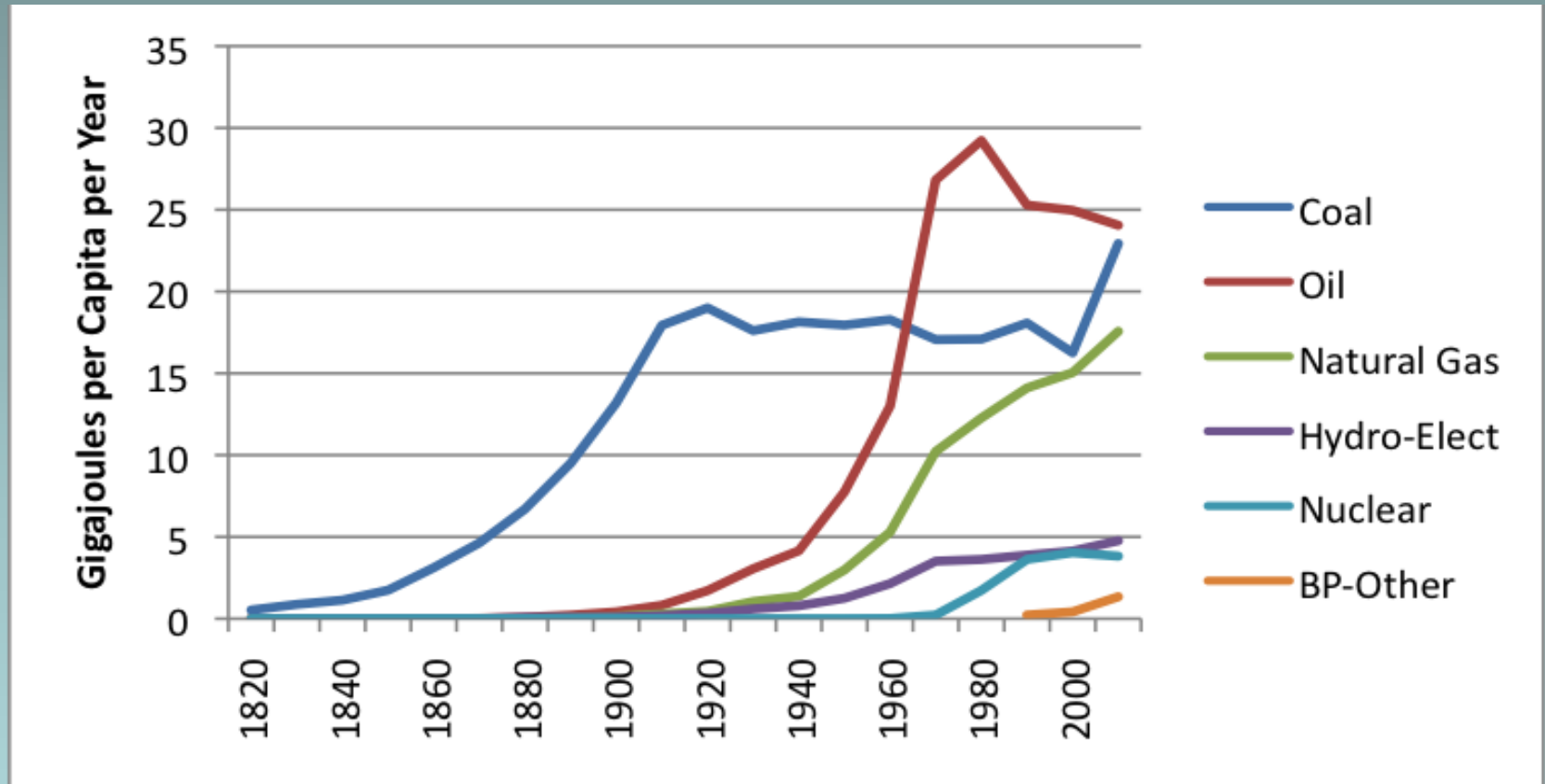
	A	B	C	D
Region	GDP	TPES	Intensity	Energy Efficiency
Germany	2,933	318	0.108	20.0%
Luxembourg	36	4	0.109	19.9%
Netherlands	647	77	0.120	18.1%
France	2,048	253	0.124	17.5%
Russia	2,206	731	0.331	6.5%
United States	14,452	2,188	0.151	14.3%
OECD	40,316	5,300	0.131	16.5%
Non-OECD	46,018	8,241	0.179	12.1%
World	86,334	13,541	0.157	13.8%
<b>Notes:</b>				
<b>GDP</b> is in billions of 2005 USD PPP				
<b>TPES</b> is total primary energy supply in million tonnes of oil equivalent				
<b>Intensity</b> is toe/000 2005 USD (PPP)				
<b>Energy Efficiency:</b> author calculation on rate of high quality energy into useful work				

**Source:** Selected 2013 Energy Statistics, International Energy Agency (2015)

# World per Capita Energy Consumption

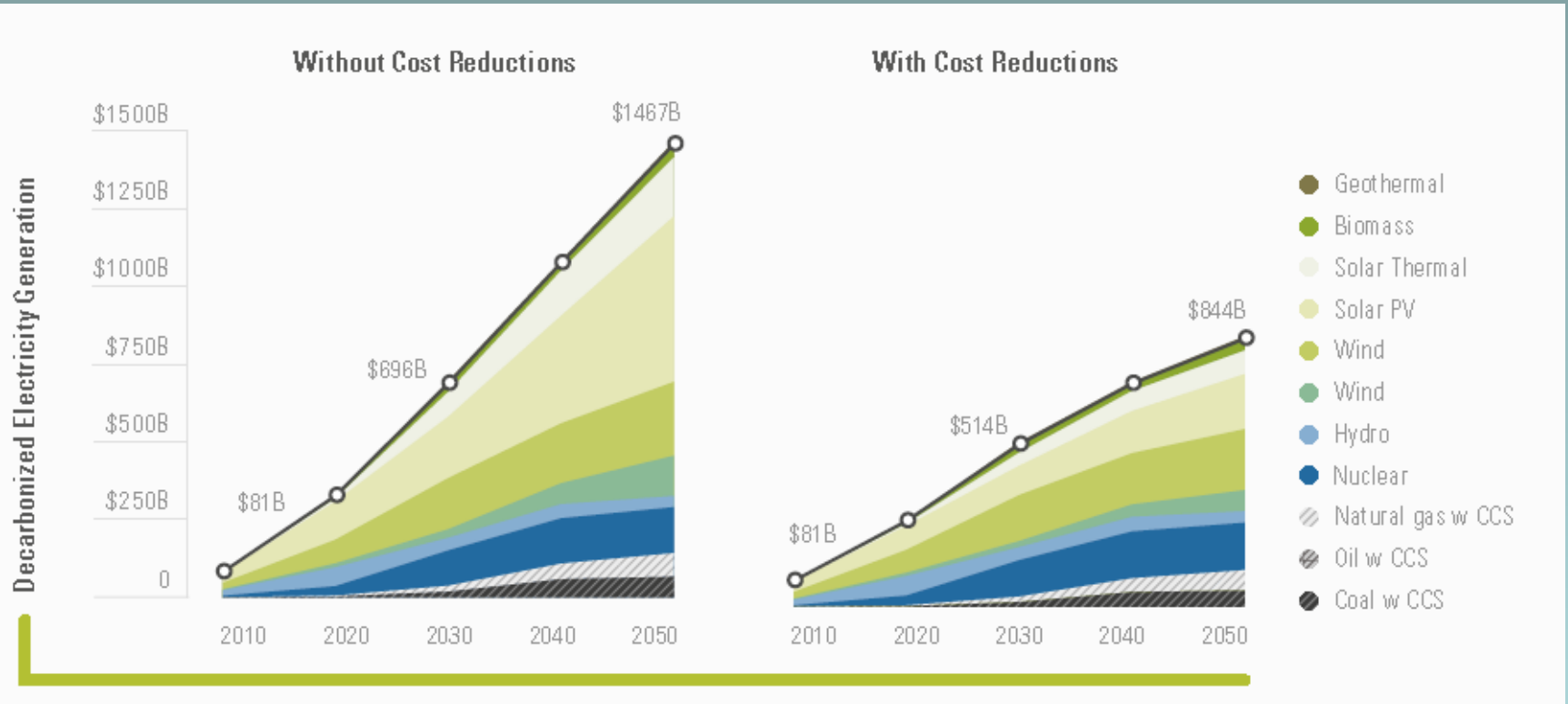


# Per Capita Consumption of Fuels



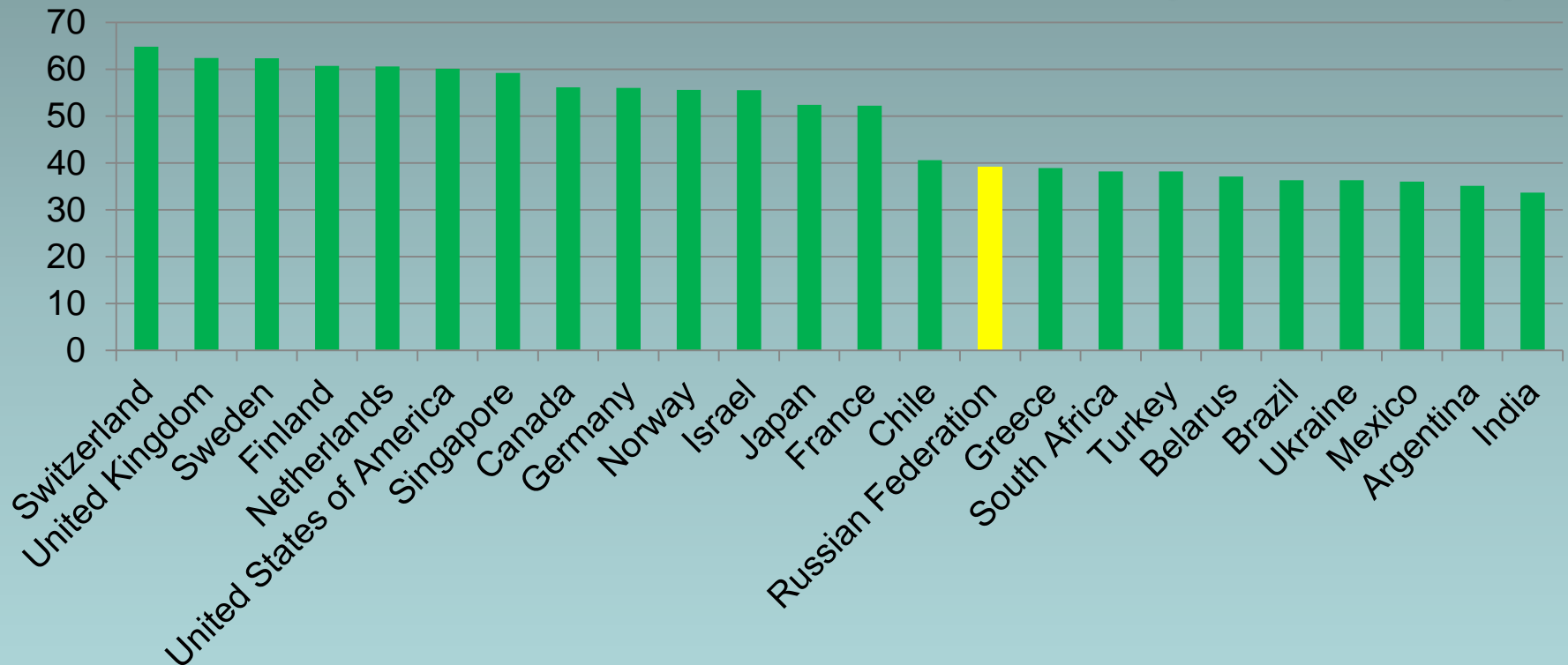
Typical energy transition of 70-100 years – And we have less than 35 years. . .

# Annual Investments: With and Without Innovations



Source: Deep Decarbonization Pathways Project (DDPP)

# Russia and the World: Global Innovation Index 2014 (49 of 140)



The Global innovation index 2014, <http://www.globalinnovationindex.org/content.aspx?page=data-analysis>

## A Further Thought on the Tough Choices

“Individuals have a natural tendency to choose from an *impoverished option bag*. Cognitive research in problem solving shows that individuals usually generate only about 30 percent of the total number of potential options on simple problems, and that, on average, individuals miss about 70 percent to 80 percent of the potential high-quality alternatives (emphasis in the original).”

Dr. Jeffrey S. Luke

*Catalytic Leadership: Strategies  
for an Interconnected World, 1998*

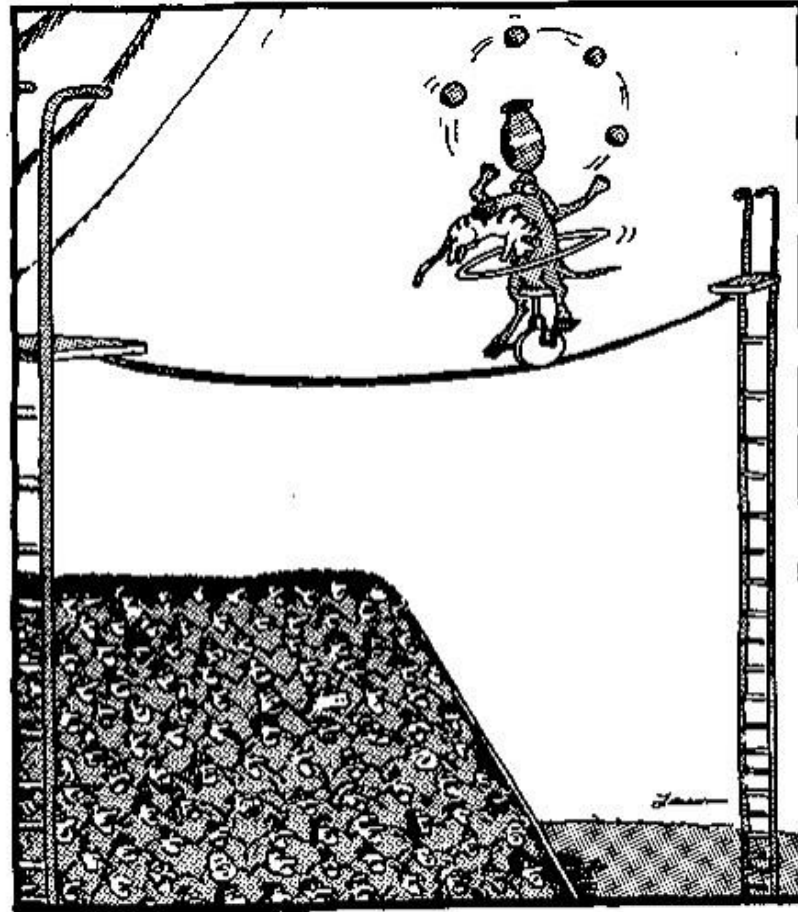


# **A Final Thought on a New Reality??**

The complete economic recovery and robust development of the World's long-term prosperity will not be possible without large increases in purposeful investment and greater levels of resource and energy efficiency – enabling the significant reduction in the full costs of energy services, and motivated by informed attitudes and more productive behaviors. It can be done. The opportunities are there. But they require imagination, innovation, and new business models for new ways of managing resources.

# Working Conclusions

- According to some indicators, Russia is (slowly) improving innovation activities (2013).
- However, it is a long way to reach high-tech world leadership in innovations and R&D.
- “Green” technologies and energy efficiencies are not priorities in Russia. The innovations are rare in the “green” tech industry.
- Obstacles and problems: both perceptions and institutions (business, political, regulatory, cultural etc.)
- And yet, the social and economic well-being of the Russian economy—indeed of the global economy—required accelerated levels of innovation and more productive investment
- There is significant work ahead!



High above the hushed crowd, Rex tried to remain focused. Still, he couldn't shake one nagging thought: He was an old dog and this was a new trick.

***The difficulty lies not with the new ideas, but in escaping the old ones. . .***

***John Maynard Keynes***

# Selected References

- **Ayres, Robert U. and Benjamin Warr.** 2009. *The Economic Growth Engine: How Energy and Work Drive Material Prosperity*. Northampton, MA: Edward Elgar Publishing, Inc.
- **International Energy Agency.** 2014. *Energy Efficiency Market Report*. Paris, France: OECD/IEA.
- **Kümmel, Reiner.** 2011. *The Second Law of Economics: Energy, Entropy, and the Origins of Wealth*. New York, NY: Springer.
- **Laitner, John A. “Skip.”** 2014. “The Link between Energy Efficiency, Useful Work, and a Robust Economy.” In: Byrne, John, and Wang, Young-Doo, eds. *Green Energy Economies*. New Brunswick, NJ: Transaction Publishers.
- **Laitner, John A. “Skip.”** 2015. “Linking Energy Efficiency to Economic Productivity: Recommendations for Improving the Robustness of the U.S. Economy.” *Wiley’s Energy Environ* 2015. doi: 10.1002/wene.135.
- **Laitner, John A. “Skip”, Steven Nadel, R. Neal Elliott, Harvey Sachs and Siddiq Khan.** 2012. *Long-Term Energy Efficiency Potential: What the Evidence Suggests*. <http://www.aceee.org/press/2012/01/aceee-report-us-better-thinking-big->

# Contact Information

## John A. “Skip” Laitner

Principal Economist and Consultant  
Economic and Human Dimensions Research Associates

President  
Association for Environmental Studies and Science (AESS)

Senior Research Fellow  
Russian Presidential Academy for National Economy and Public Administration

Senior Fellow  
CNA Public Policy Research Institute for Energy, Water, and Climate

Tucson, Arizona USA 85750  
c: (571) 332-9434  
Email: EconSkip@gmail.com