Welcome to 4th quasi Annual meeting on biophysical economics

Charles Hall
SUNY College of Environmental Science and Forestry
Syracuse N.Y.

What is Biophysical Economics?

…a system of economic analysis that is based on the biological and physical (as opposed to social) properties, structures and processes of real economic systems as its conceptual base and fundamental model. It acknowledges that the basis for nearly all wealth is nature, and views most human economic activity as a means to increase (directly or indirectly) the exploitation of nature to generate more wealth.

As such, it focuses on the structure and function of real economies from an energy and material perspective, although it often considers the relation of this structure and function to human welfare and to the money (i.e. dollar) flows that tend to go in the opposite direction to energy (Odum, 1972).

- Hall and Klitgaard *International Journal of Transdisciplinary Research Vol. 1, No. 1, 2006*
  Pages 4-22

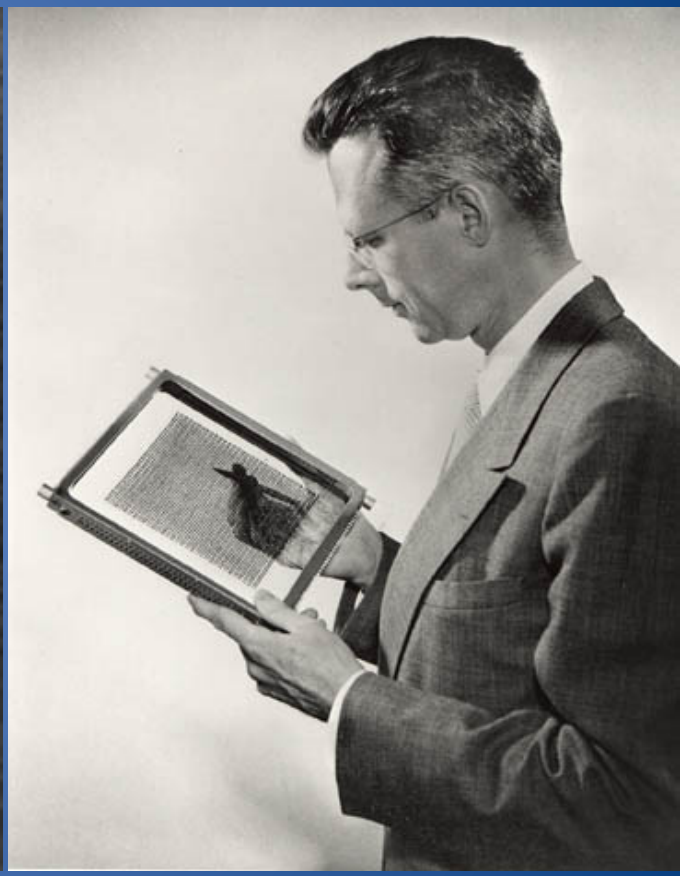
- It is not Ecological Economics
- Its not particularly “green” (or is it)

- …although it might be considered within the meaning of Costanza’s original definition
- It repudiates the basis of conventional economics
- Its just common sense

Major influences

H. T. Odum

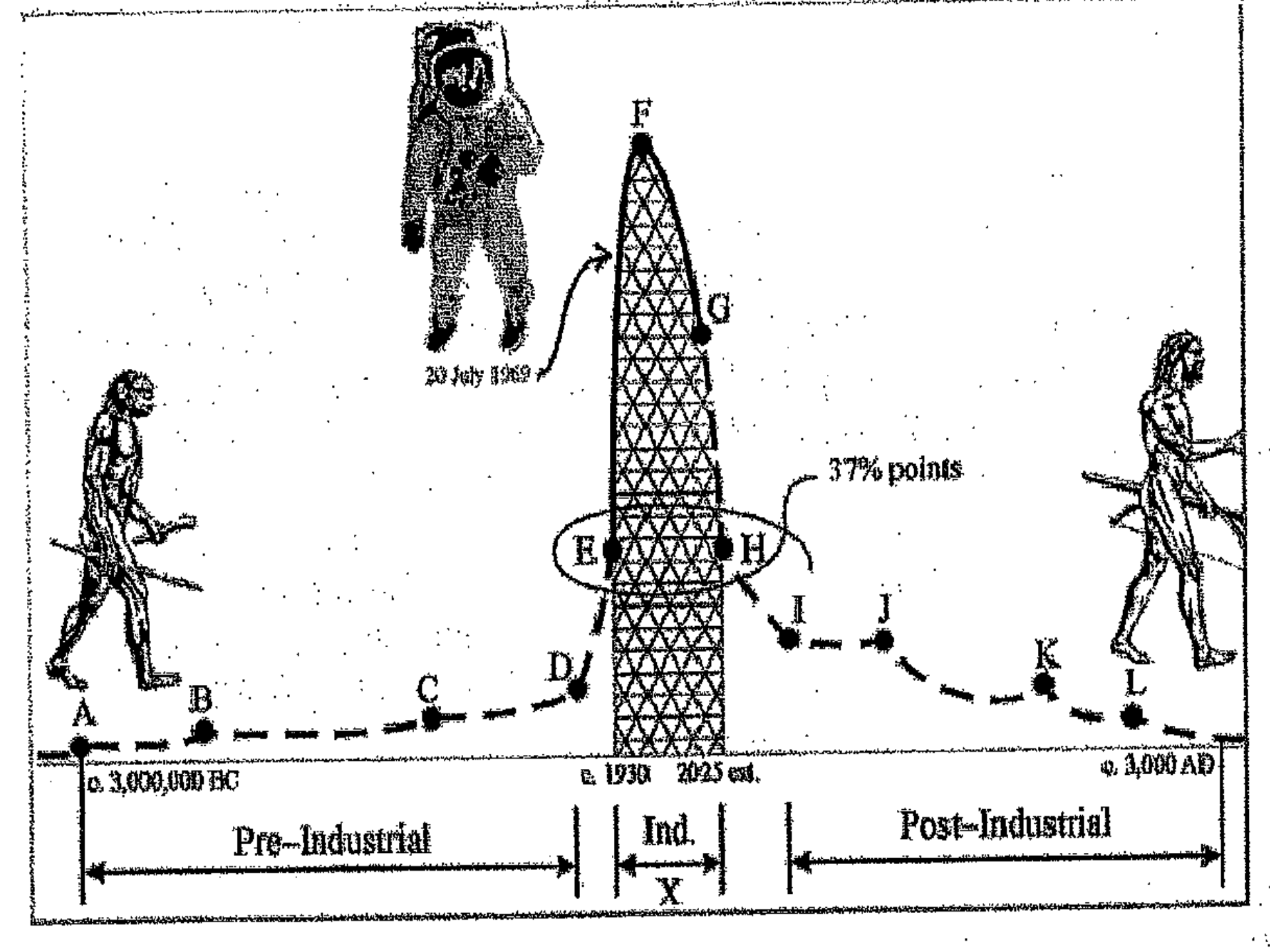
M. King Hubbert



Jay Forrester

33 HP animal power (controlled by 5 workers plus
Land for feed, Human work, Water and soil, Stables

200 HP mechanical power (controlled by 1 worker)


F
G
20 July 1969
37% points
E
H
A
B
C
D
I
J
K
L
c. 3,000,000 BC
c. 1930
2025 est.
c. 3,000 AD
Pre-Industrial
Ind.
Post-Industrial
X

Do we want to organize????

ENERGY RETURN ON INVESTMENT: STATE OF THE FIELD : for fourth Biophysical Economics conference, Burlington

Charles Hall

SUNY Environmental Science and Forestry

In the past year and a half there has been a lot of activity in EROI:

1) We finally got some government $$ (from UK)

2) Many publications

3) and some attention! :


22
5 26

➢ Publications:

23 paper special issue of the Journal Sustainability on EROI
Four books on EROI Published
Ten other Journal articles

Also Brandt, King, etc.

Heun M. and M. deWit Energy return on (energy) invested (EROI), oil prices, and energy transitions

Books

- Hall, C.A.S., and K. Klitgaard. 2011. Energy and the Wealth of Nations: Understanding the Biophysical Economy. Springer, NY.
- Prieto, P. Hall, C.A.S. 2012. Spain's Photovoltaic Revolution. Springer, NY.
- Hu, Y., L. Feng, C.A.S. Hall. 2012. The Chinese Oil Industry: History and Future.
- Pascualli, Carlos and Hall, C.A.S. The First Half of the Age of Oil. 2012. Springer, NY.

Publications

- Hall group:
- Townsend, J., Hall, C.A.S., T. A. Volk, M. Serapiglia, D. Murphy, G. Ofezu, B. Powers and A. Quaye. Energy return on investment (EROI) of current and alternative liquid fuel sources and their implications for wildlife science. Journal of Wildlife Science. (In Press).
- Hamilton, A., A. Maxwell, C.A.S. Hall, S. Balogh. Efficiency of Edible Agriculture in Canada and the U.S. Over the Past 30 Years. Energies. 2012
- Poisson, A., C.A.S. Hall, Time Series EROI for Canadian Oil, Gas and Tar Sands. Energies. 2012
- Murphy, D. Energy Return on Investment of Oil Production and Its Impact on Long-Term Economic Growth . Submitted to the Philosophical Transactions of the Royal Society.

I. Conceptual Issues:

1. Hall, Charles. Introduction to special issue

2. Murphy, David, Charles Hall and Cutler Cleveland: Order from Chaos: A Preliminary Protocol for Determining EROI for Fuels.

3. Gupta, Ajay and Charles Hall: A brief review of previous studies of EROI.

4. Dale, Michael, Susan Krumdieck and Pat Bodger. A Dynamic Function for Energy-Return-on-Investment.

5. Henshaw, Phil, Carey King, and Jay Zarnikau: System Energy Assessment (SEA), Defining a Standard Measure of EROI for Energy Businesses as Whole Systems.

6. King, Carey and Charles Hall: Relating financial

II. EROI for Conventional Fossil Fuels:

8. Guilford, Megan, Peter O'Conner, Charles A. S. Hall and Cutler J. Cleveland: A new long term assessment of EROI for U.S. oil and gas.

9. Grandell, Leena. Charles A.S. Hall and Mikael Höök. Energy return on investment for Norwegian oil and gas in 1991-2008.

10. Brant, Adam: Oil depletion and the energy efficiency of oil production: The case of California.

11. Yan, Hu, Feng, Lianyong, Charles Hall and Tian Dong:
Empirical Analysis of production and EROI from China's largest oil field –the Daqing Oil Field.

12. Freise, Jon E.F. : The EROI of Conventional Canadian Natural Gas Production.

13. Sell, Bryan, Charles Hall and David Murphy: EROI for traditional natural gas in Western Pennsylvania.

14. Moerschbaecher, Matt, and John Day. Return on investment for ultra-deep water oil in the Gulf of Mexico: Financial and a preliminary energy analysis.

III. EROI for Other Fuels:

15. Hall, Charles, Bruce Dale and David Pimentel: Seeking to understand the reasons for different EROI assessments of biofuels.

16. Cutler J. Cleveland and Peter A. O'Connor: Energy Return on Investment (EROI) of Oil Shale

17. Pracha, Ali Shahrukh and Tim Volk: EROI or Edible Energy return on fossil energy invested for wheat and rice in Pakistan. An edible energy return on investment (EEROI) analysis of wheat and rice in Pakistan.

18. Callarotti, Roberto C. EROI for the electrical heating of methane hydrate reservoirs.

IV. Looking Forward:

19. Lambert, Jessica and Gail Lambert: Predicting the Psychological Response of the American People to Oil Depletion and Declining EROI.

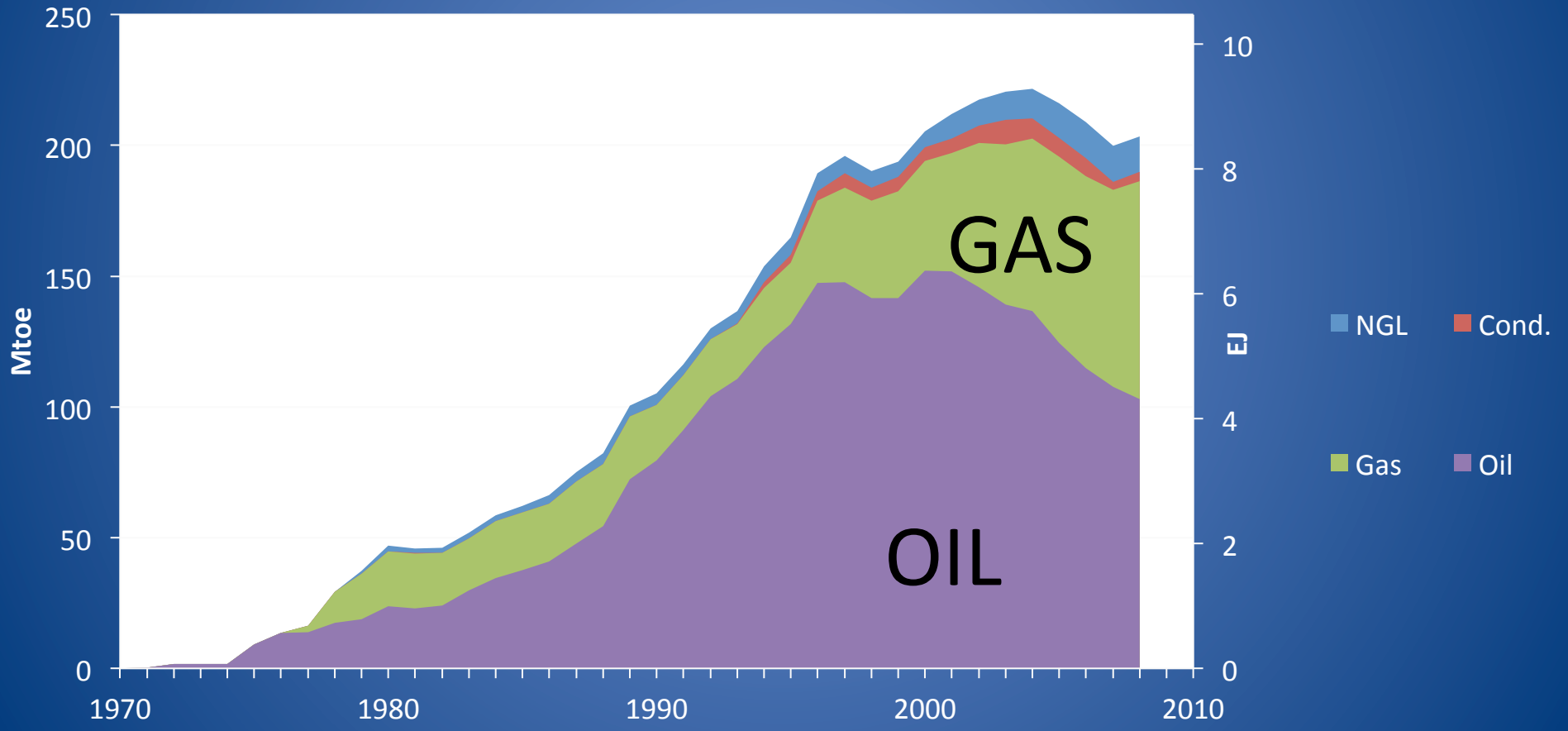
20. Deng, Shinuo and George Tynan: Implications of Energy Return on Energy Invested on Future Total Energy Demand.

21. Yannis Ikessides and David Wade: Deriving an improved, dynamic EROI to provide better information for energy planners

22. Jack Manno: Looking for a silver lining: the possible positives of declining EROI

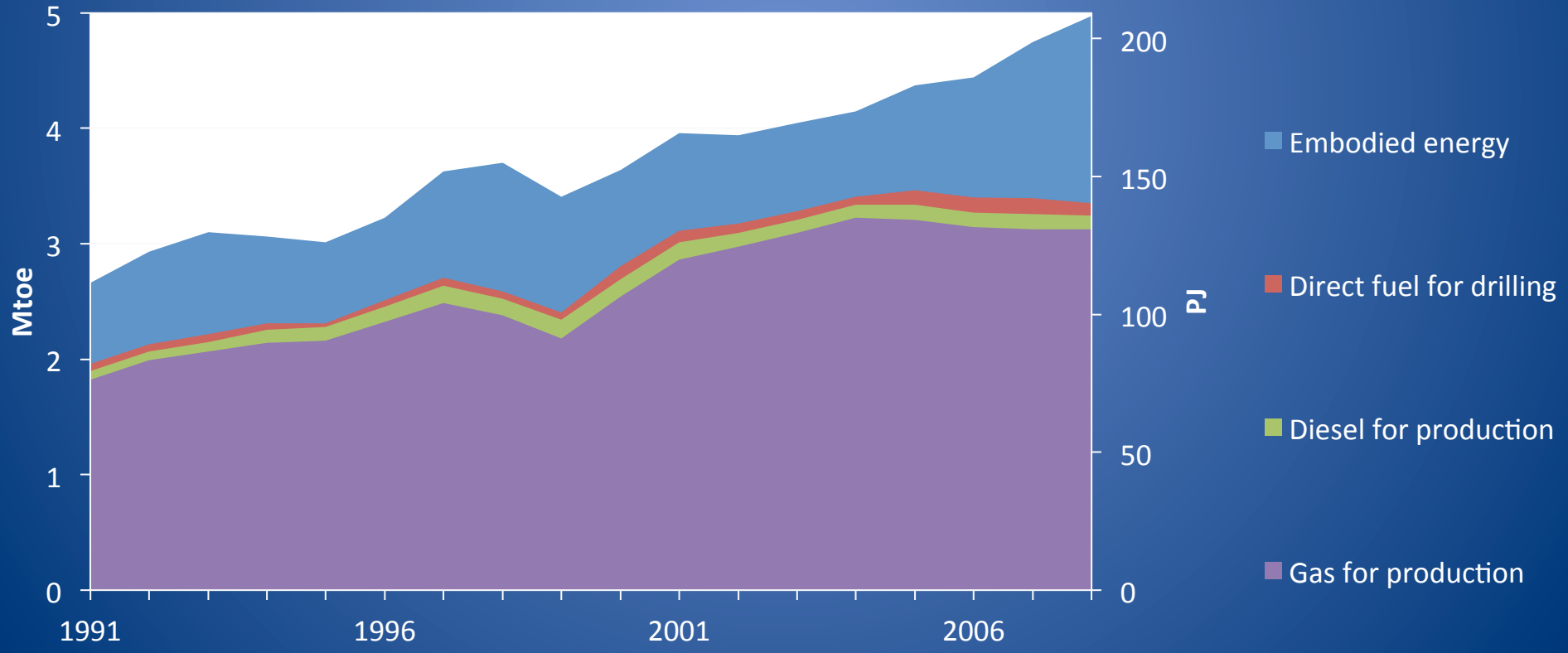
23. Charles Hall: Synthesis.

Petroleum production in Norway in 1970 – 2008

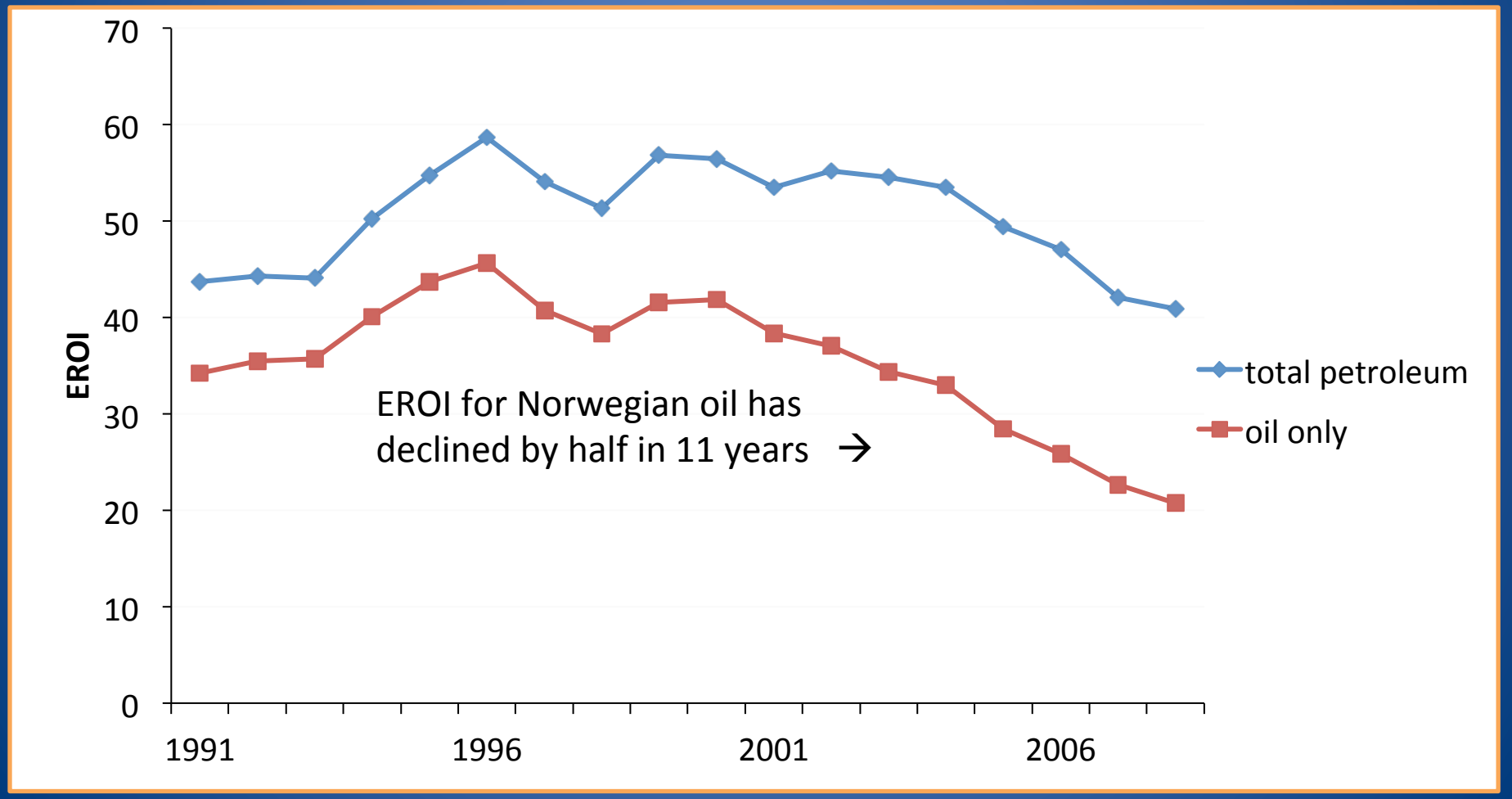


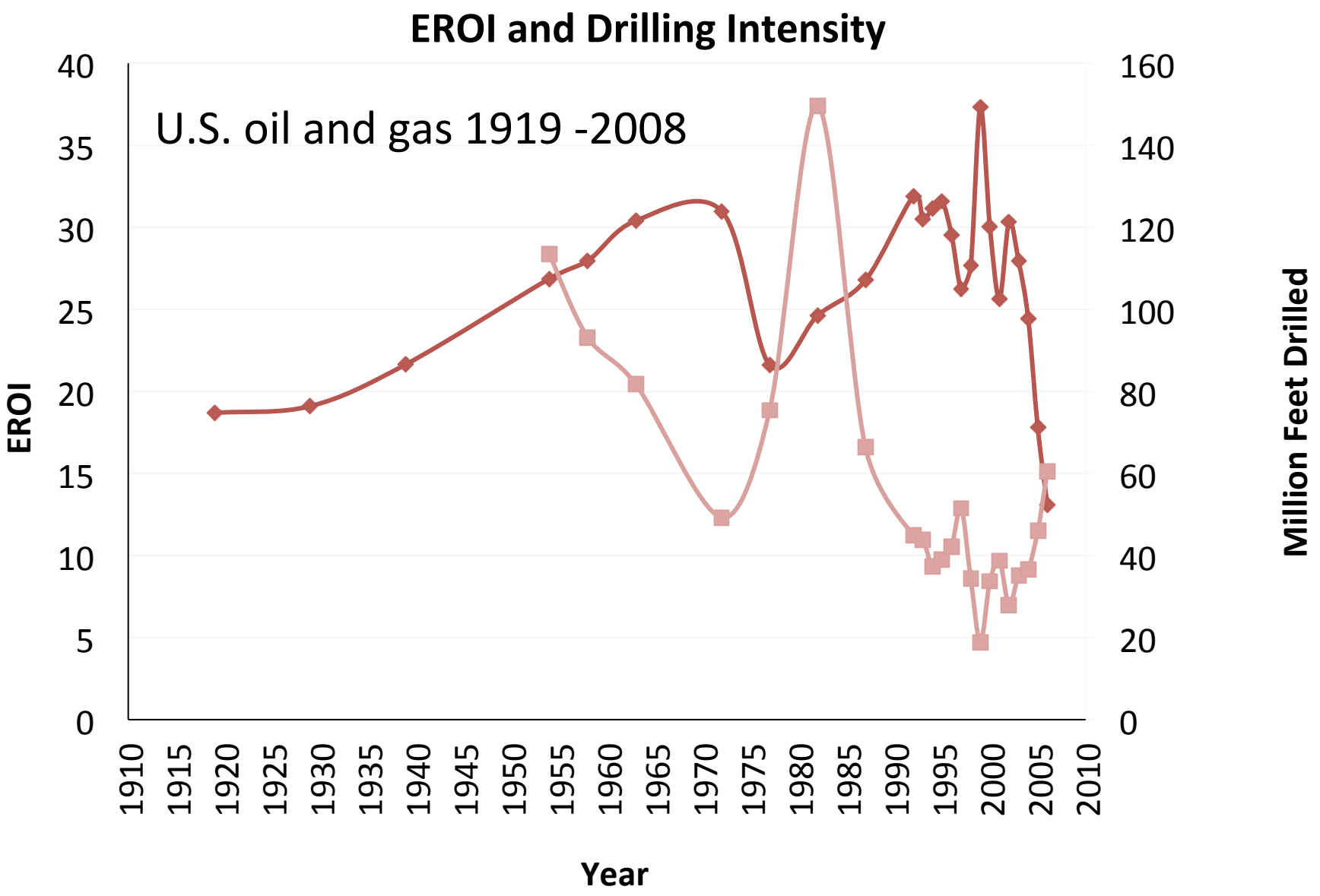
Energetic cost of petroleum production in Norway in 1991 – 2008.

Leena Grandell

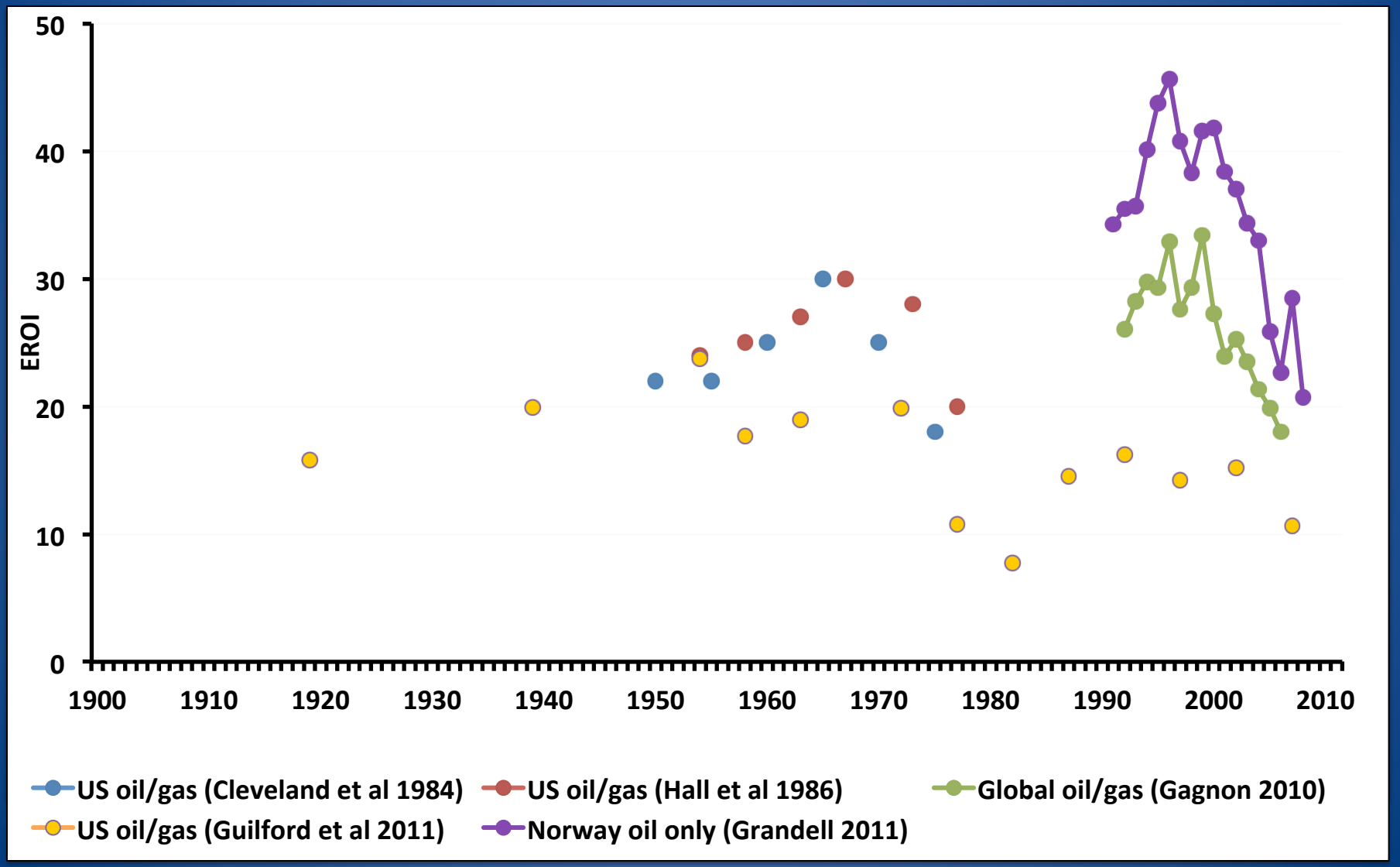


EROI of Norwegian petroleum production in 1991 – 2008

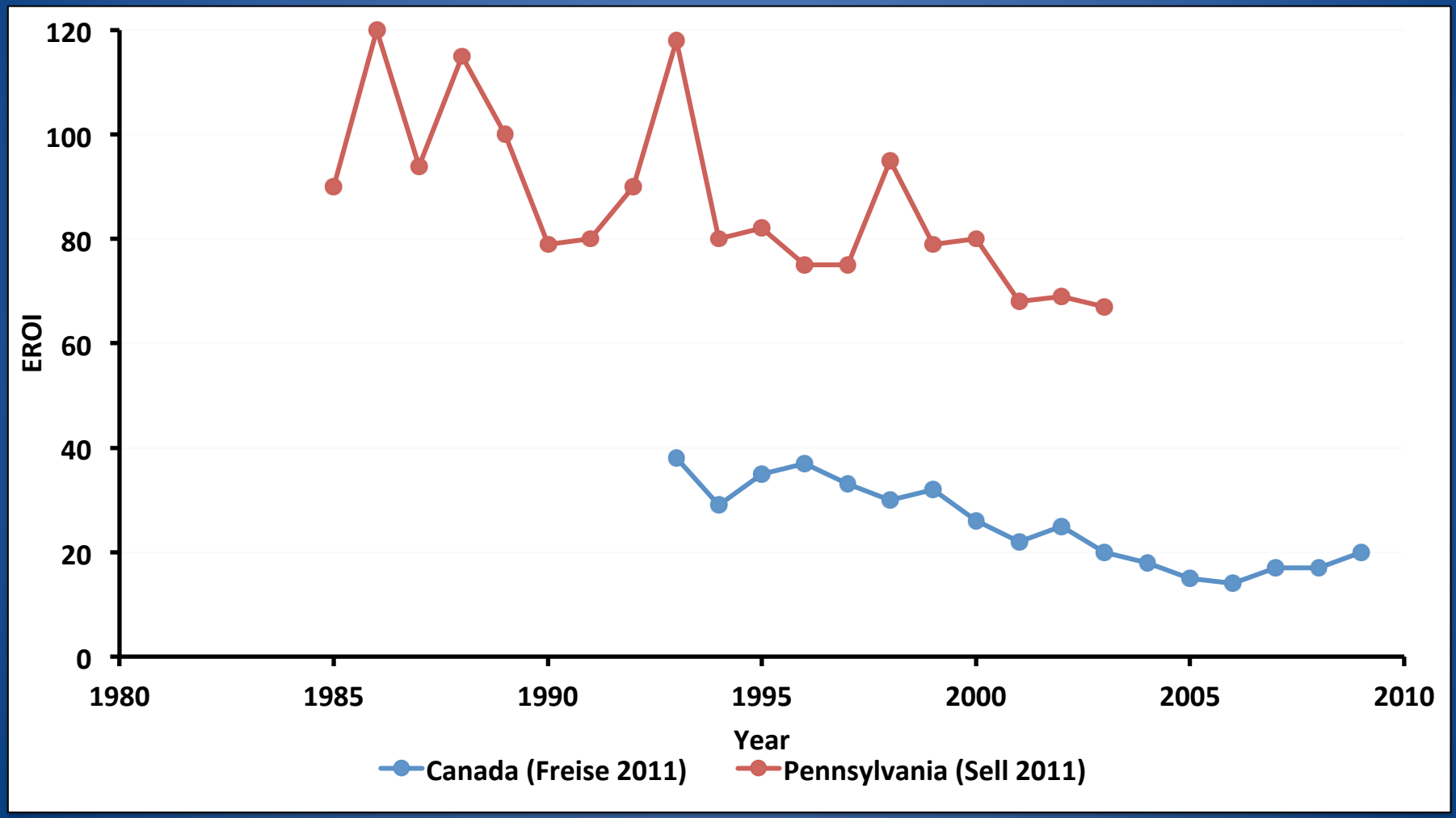



EROI and Drilling Intensity
U.S. oil and gas 1919 -2008
EROI
Million Feet Drilled
Year
0
5
10
15
20
25
30
35
40
0
20
40
60
80
100
120
140
160
1910
1915
1920
1925
1930
1935
1940
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010

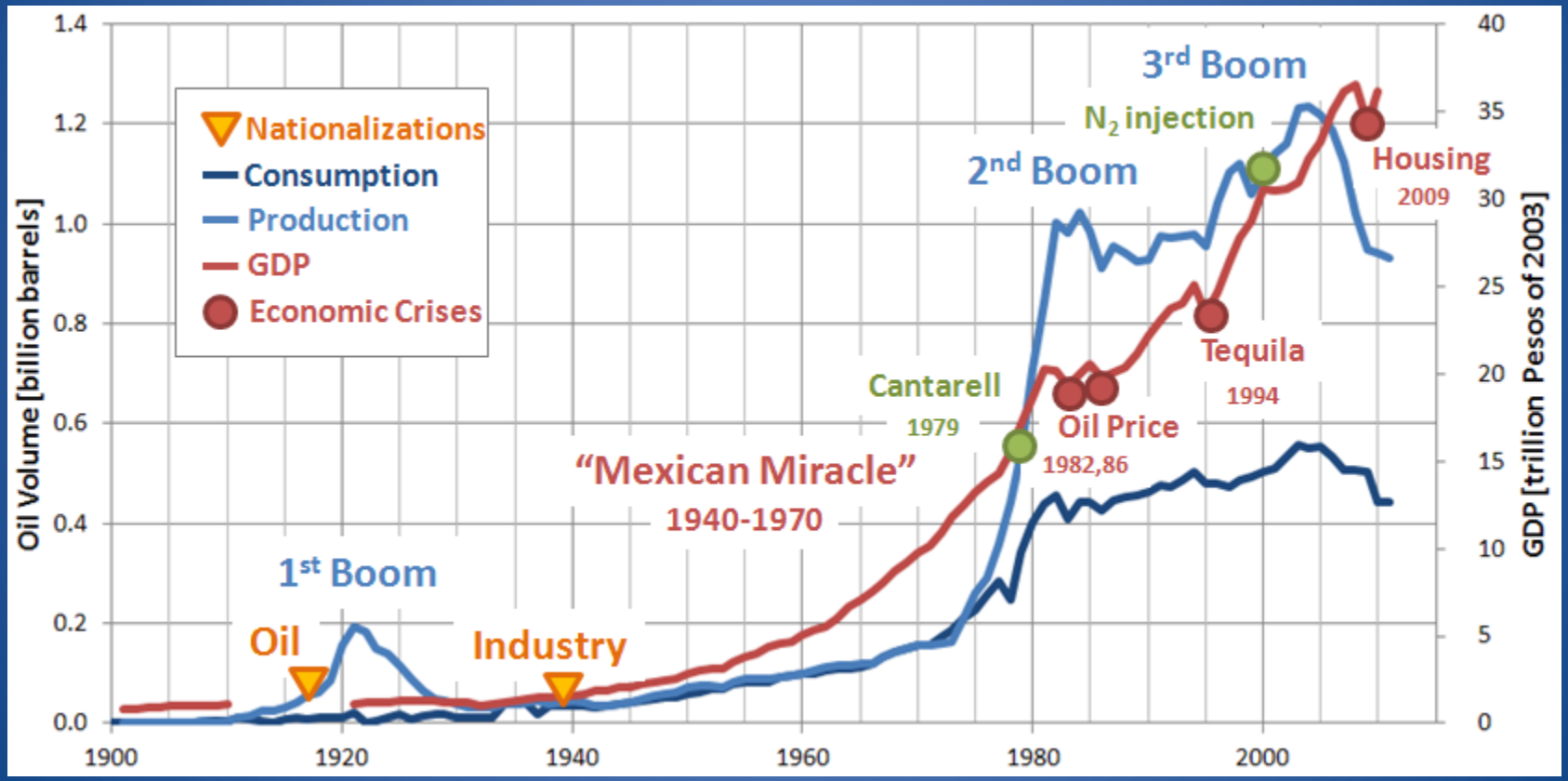
EROI for Oil: US and other



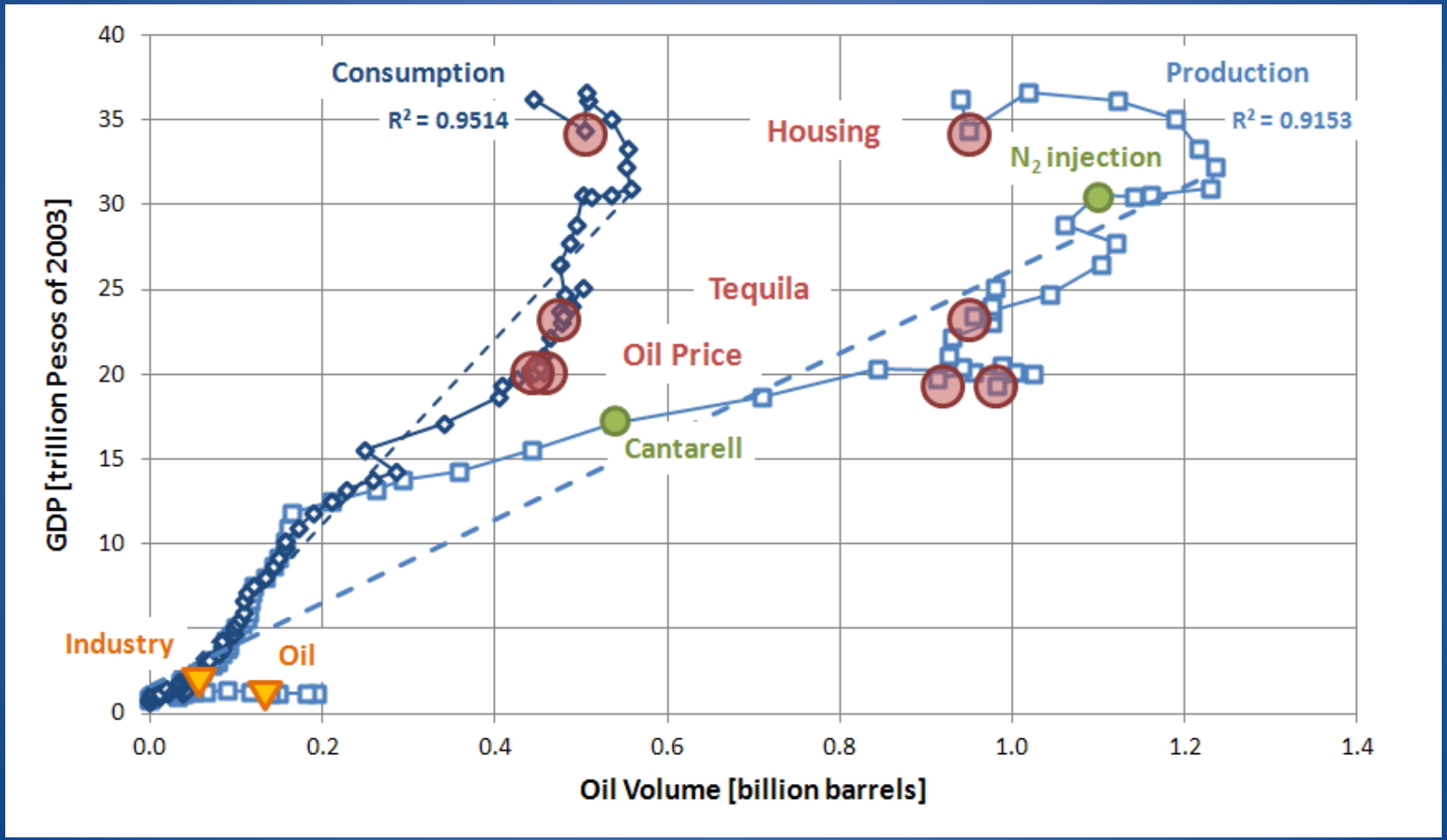
Natural Gas


120
100
80
60
40
20
0
EROI
1980
1985
1990
1995
2000
2005
2010
Year
Canada (Freise 2011)
Pennsylvania (Sell 2011)

Mexico: Oil and GDP (1900-2011)



Oil vs. GDP (1900-2011)



Concluding Remarks
and future research

- Wealth depends on (oil) control* rather than abundance
  - 1st boom (1909-21): controlled by foreign companies
  - **Industrialization era (1940-70): protectionism***
  - 2nd boom (1974-82): indebtedness and price collapse
  - Economic crises (1982, 86)
  - Structural adjustment (1986-94): neoliberalism
  - 3rd boom (1994-2004): debt repayment and taxation
  - Post-Cantarell era: private investments and market pricing
- Oil can be used as a financial asset to finance debt and public expenditure
  - Oil revenues represent 40% of federal budget
  - Oil revenues have delayed tax reform in Mexico
  - Little influence on international oil prices
  - Little capacity to invest the oil at home
- Privatization: efficiency or revenues?
- What if oil was managed in a more democratic way?

Conventional Oil (and gas) Initial Reserves:
Proved plus probable Source Jean Laherrere

	number fields	oil Gb	NG Tcf
Africa	3560	217	716
Asia	4900	139	941
CIS	4940	258	2156
Europe	5190	100	676
Latin Am	4770	280	778
MiddleEast	1530	733	3233
US&Canada			
F rontier	600	50	144
non frontier	?	208	1482
WORLD	?	1985	10126

conventional oil = crude oil less extra-heavy oil

By comparison:

Used so far at end 2011	1163
U.S. use per year	7
Bakken reserves	4-6 (USGS) to 24 (optimistic)
Eagle Ford reserves	3.35 (USGS) to 21(optimistic)

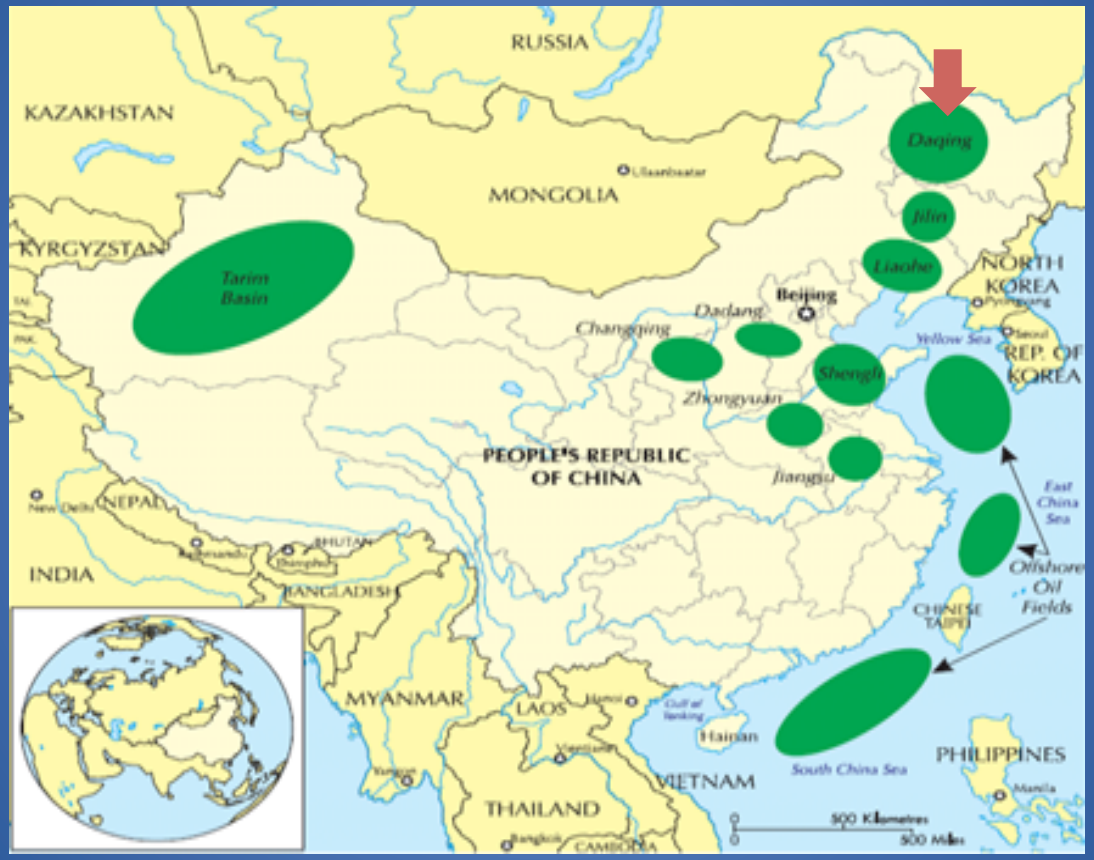
Gas: Marcellus ??? 1.1 BCf per well

Thus none of these new fields are important relative to conventional reserves.
They are useful but not game changers at all.

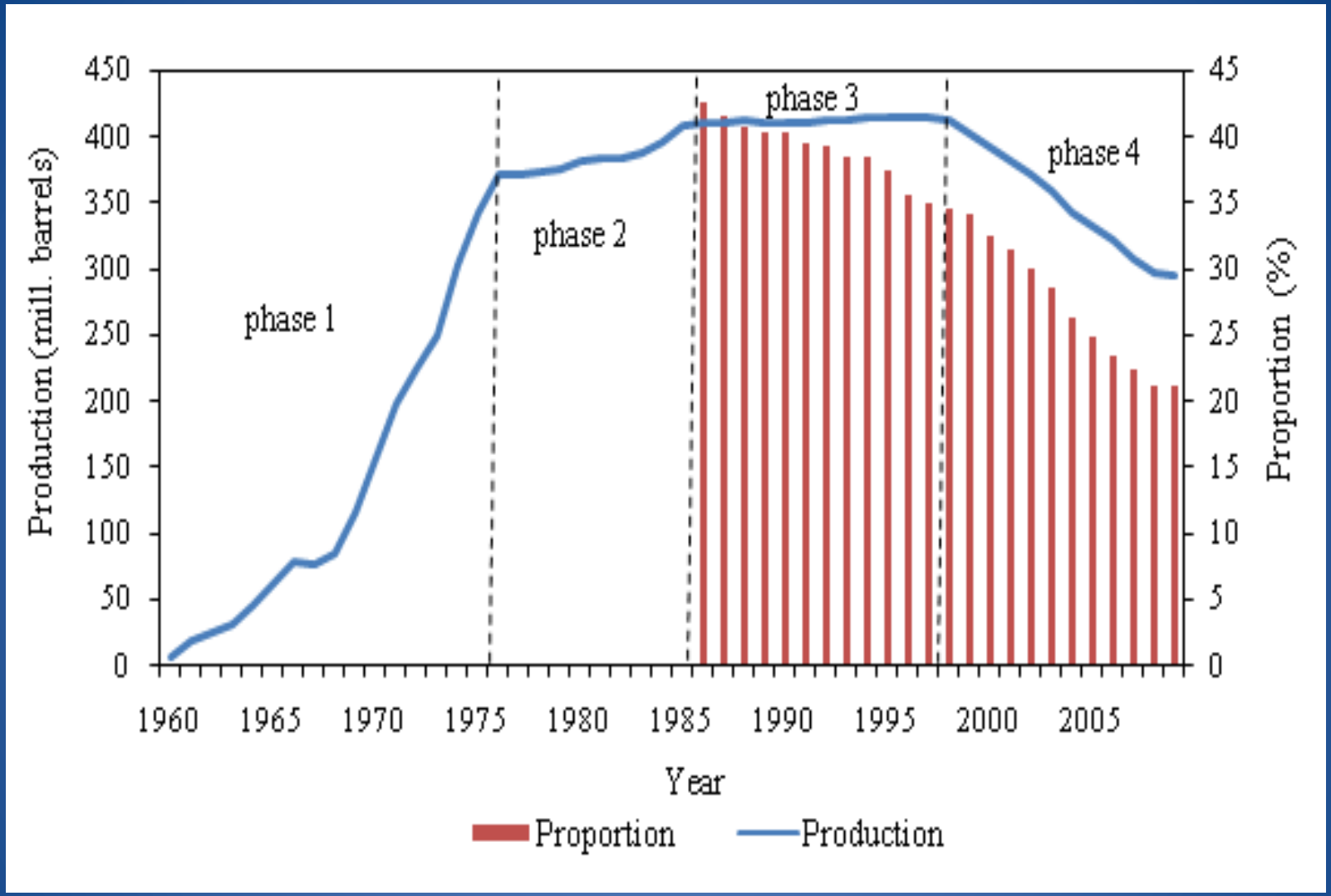
EROI Analysis of China

Yan Hu, China University of Petroleum
Charlie Hall SUNY ESF

1. EROI of Daqing Oil Field in China

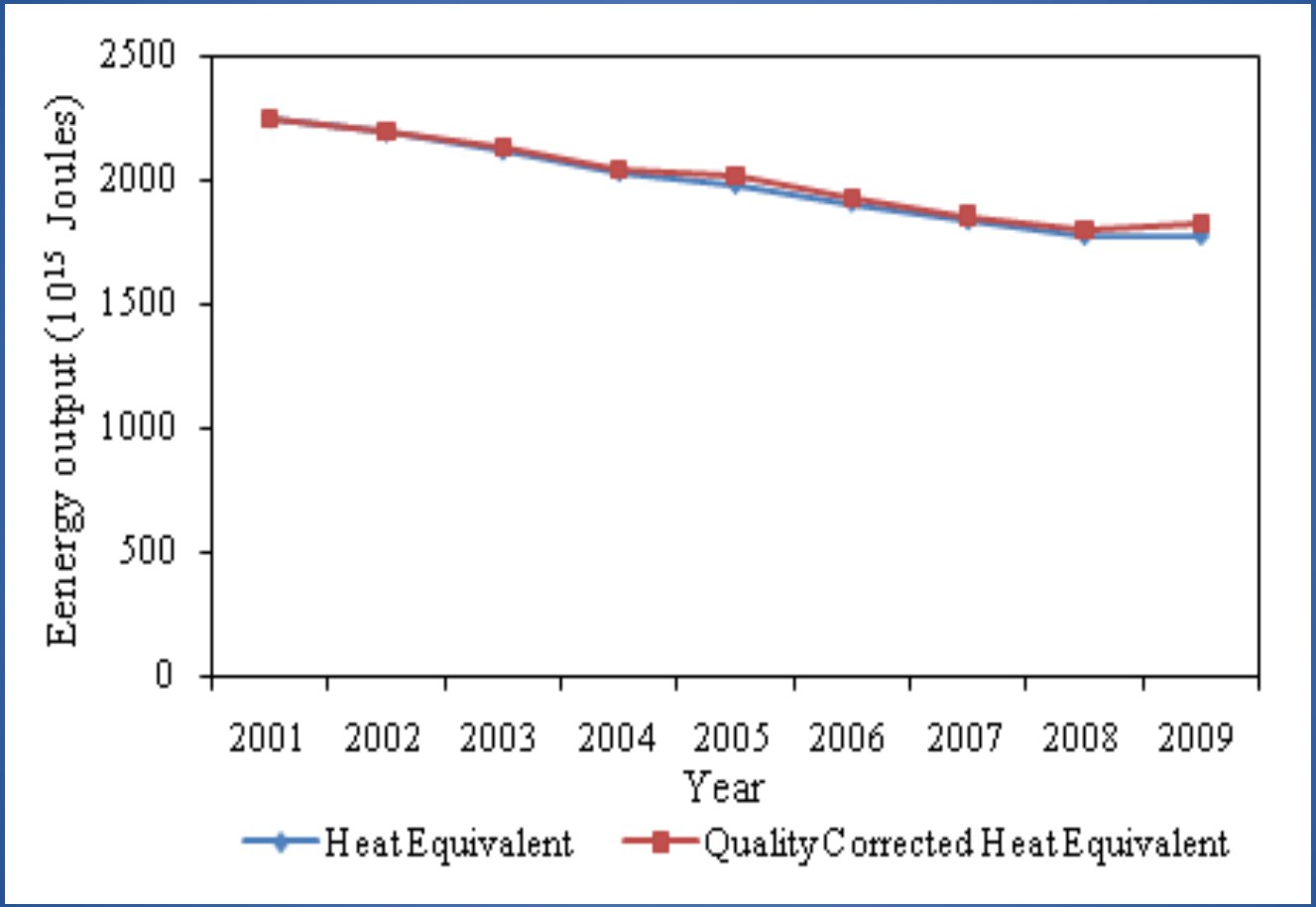


The location of Daqing and other oil and gas fields

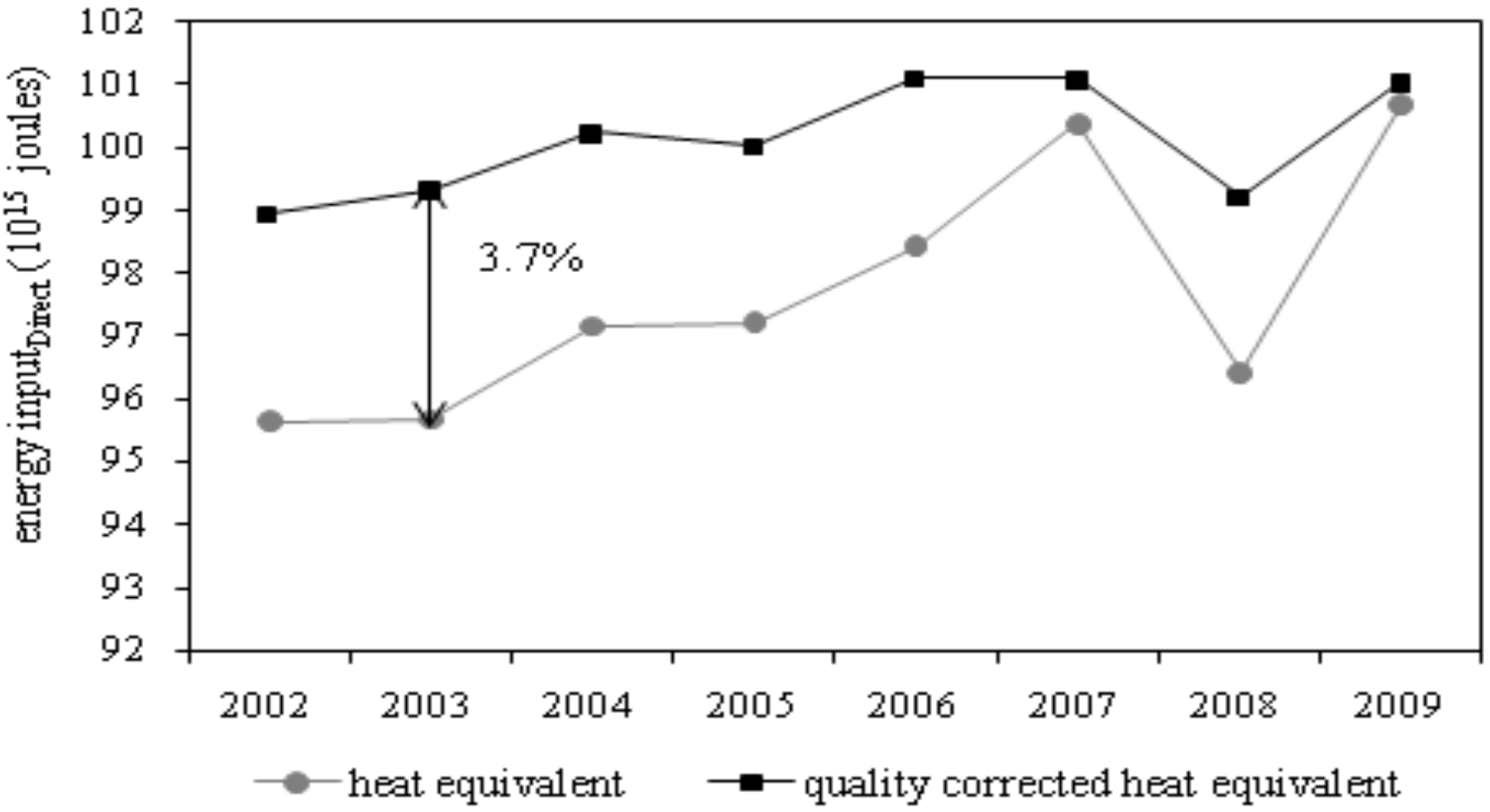


Oil production of the Daqing oil field (blue line) in million barrels per year, and its proportion of total national production (red bars).

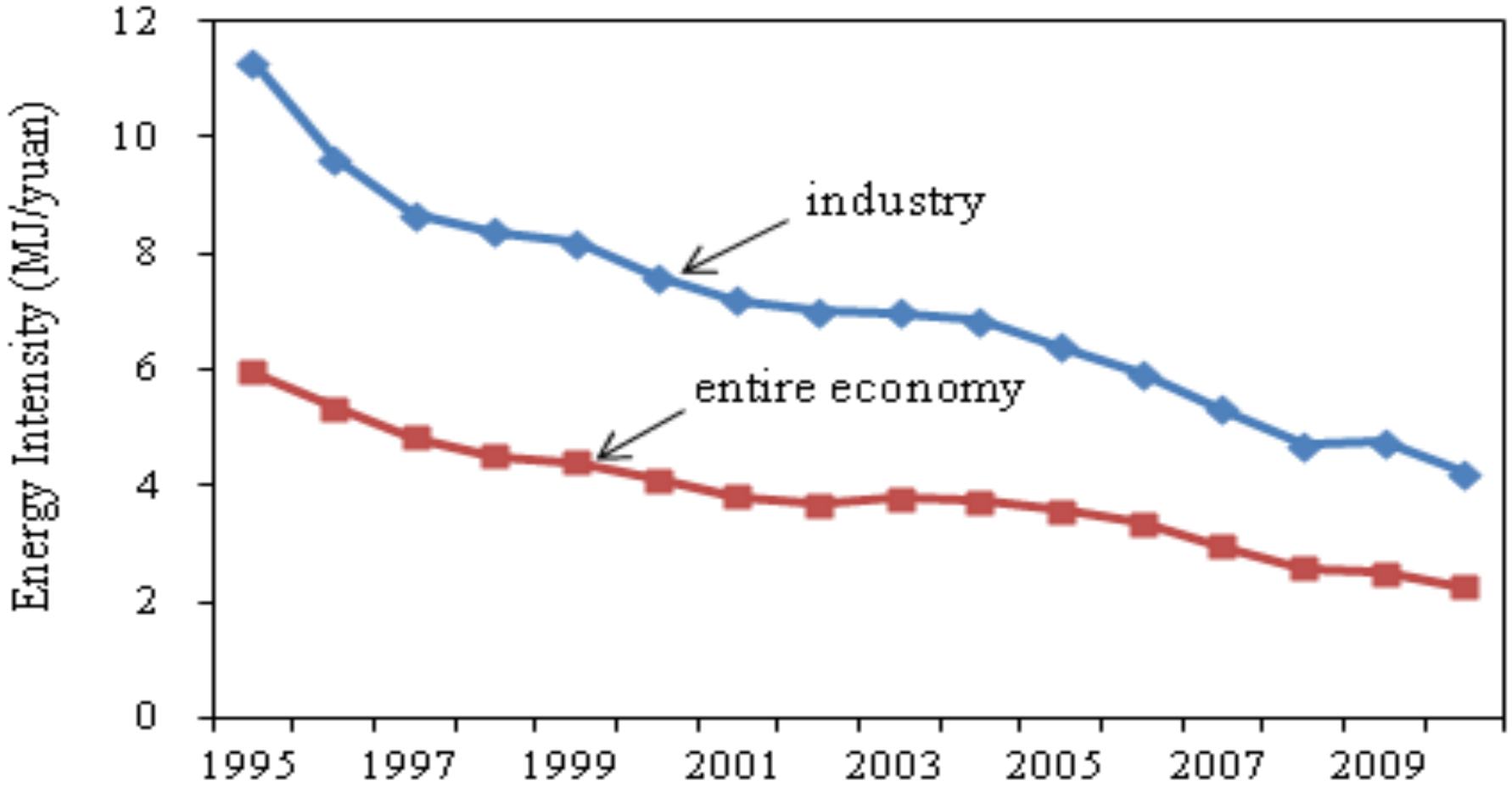
Energy Output -- with and without quality correction

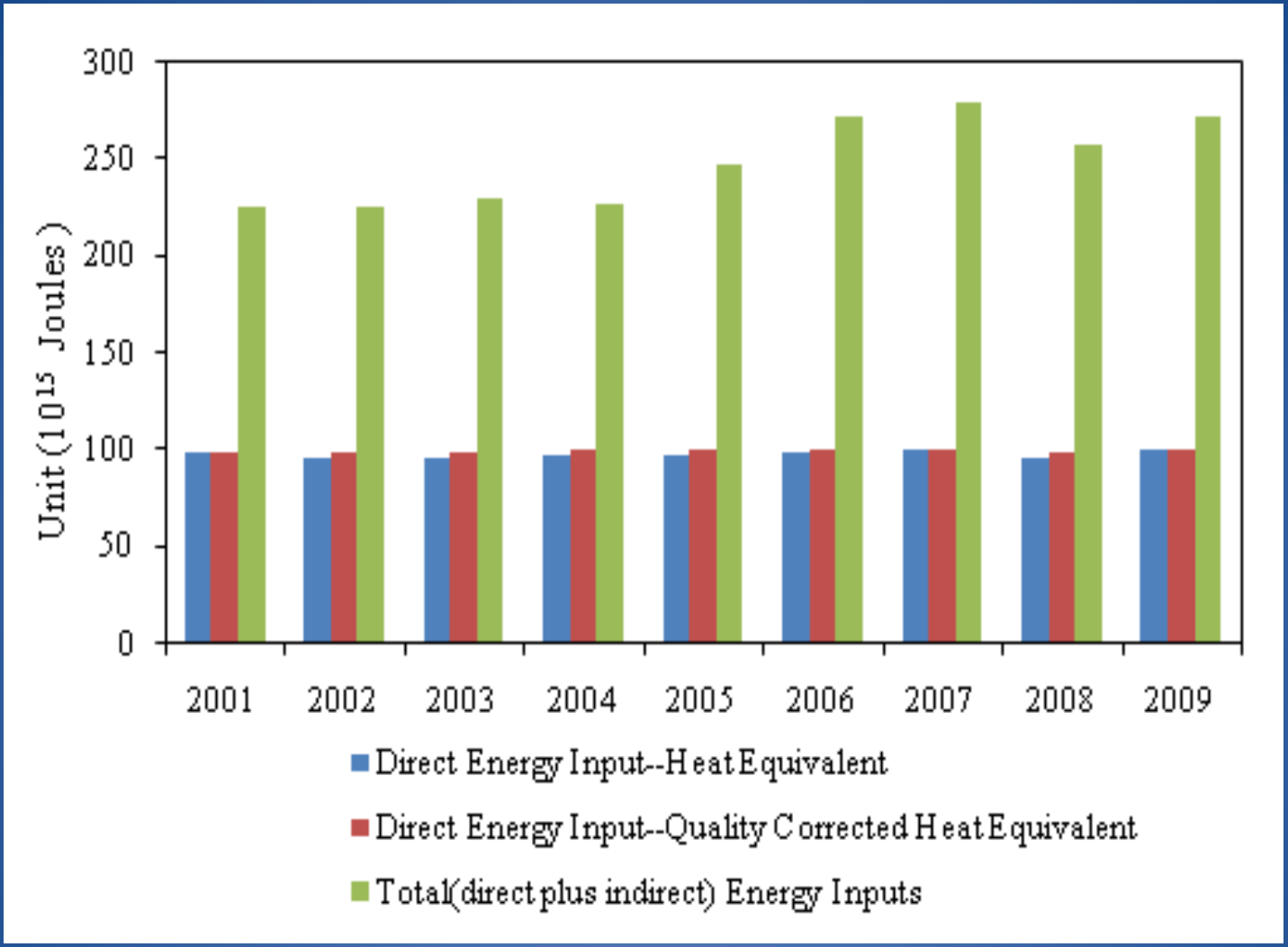


Direct Energy Inputs for the Daqing oil field in heat equivalents and quality-corrected heat equivalents



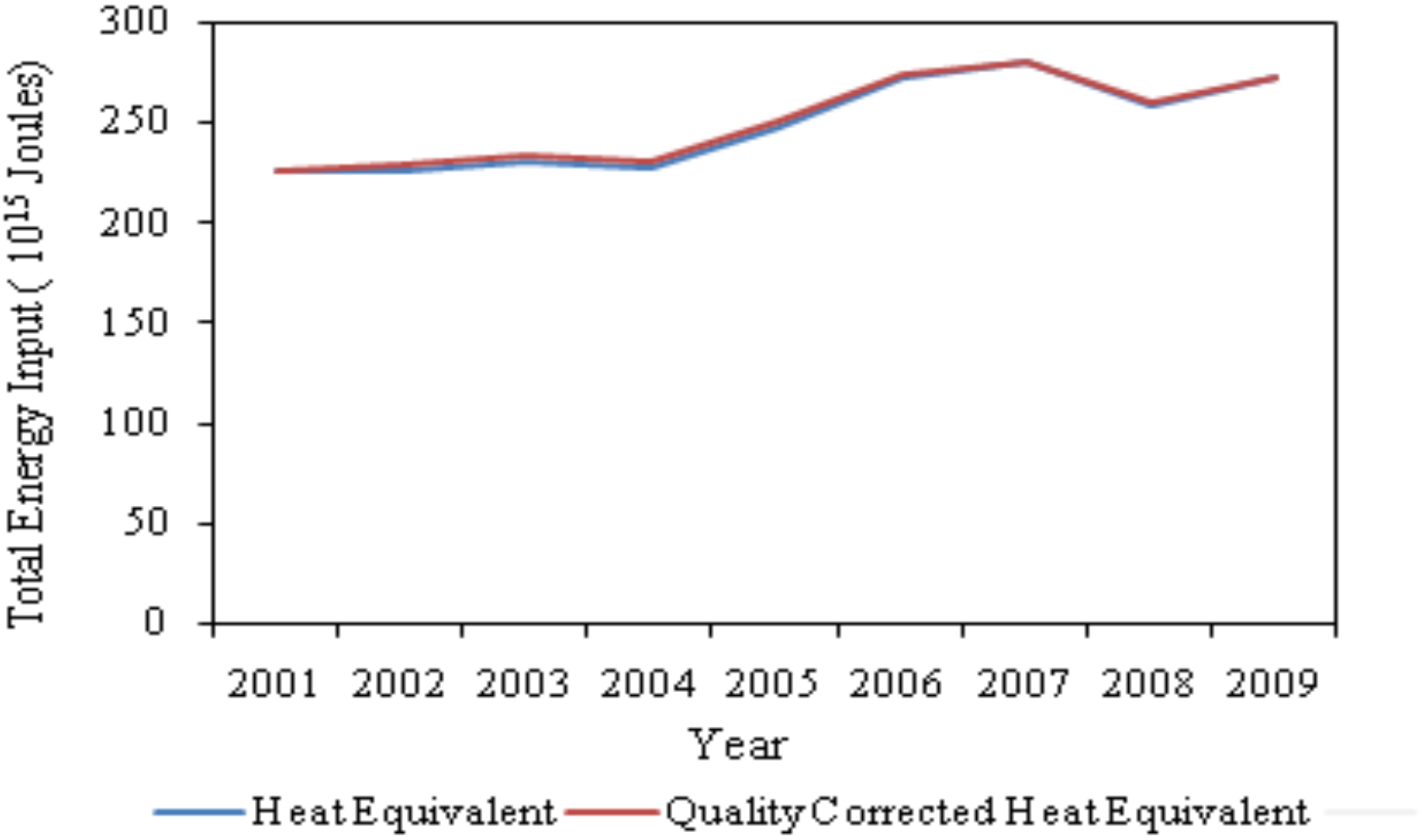
Energy Intensity of industry and the entire economy in China. Most of the apparent decline reflects inflation.



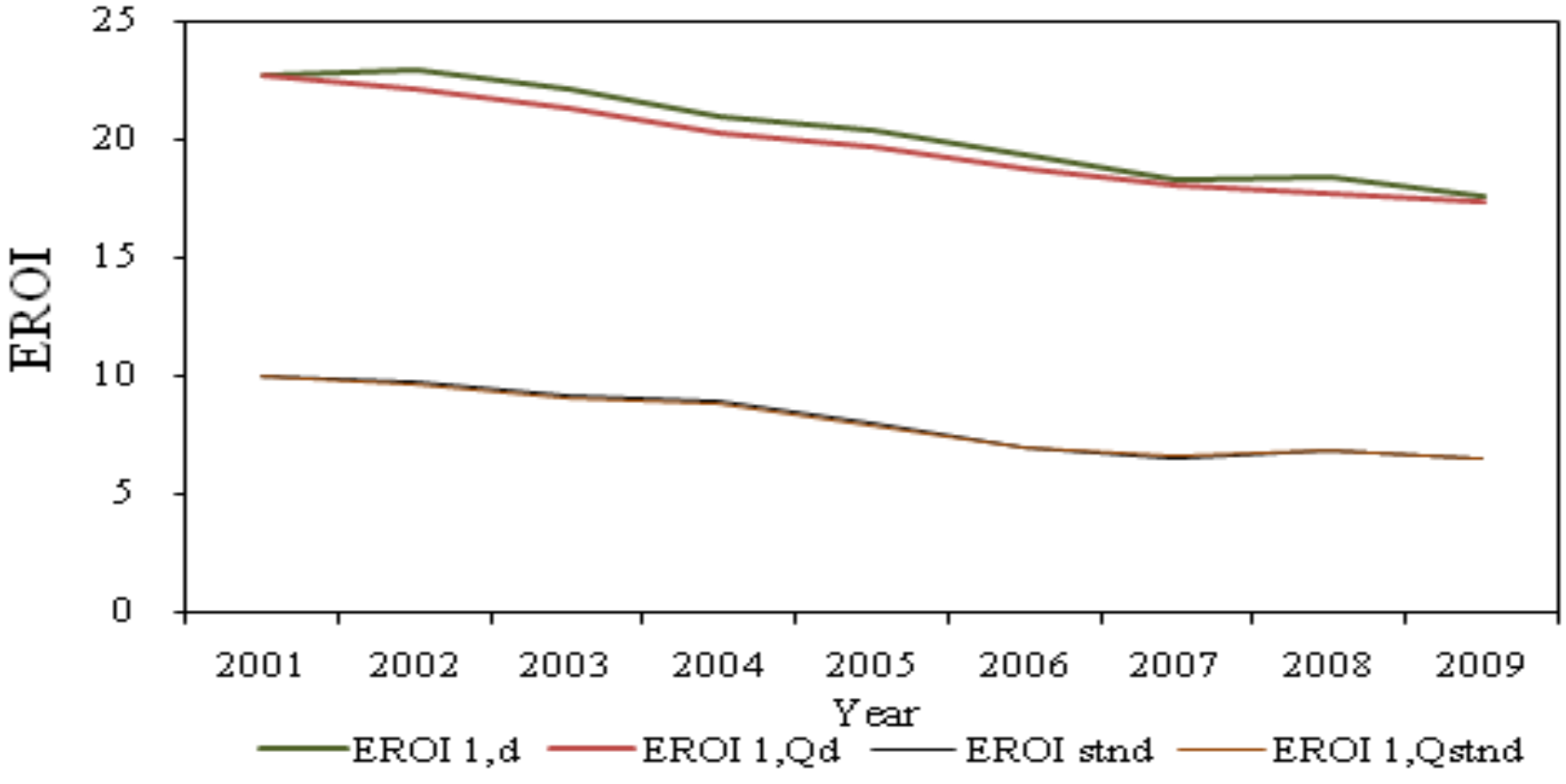


Comparison of direct energy input (heat equivalent and quality-corrected heat equivalent) and total energy inputs (heat equivalent)

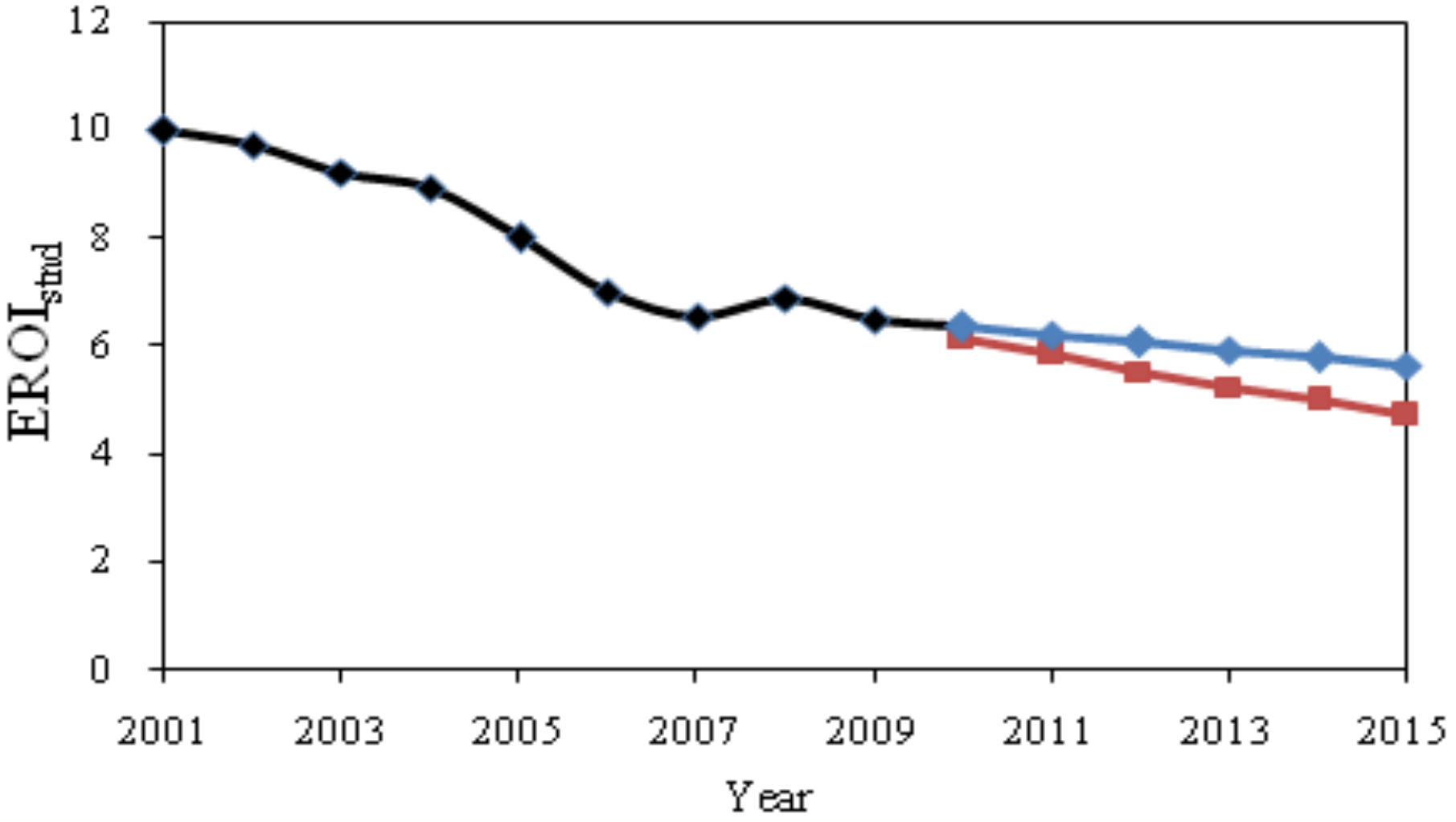
Total Energy Inputs (heat equivalent and quality-corrected heat equivalents



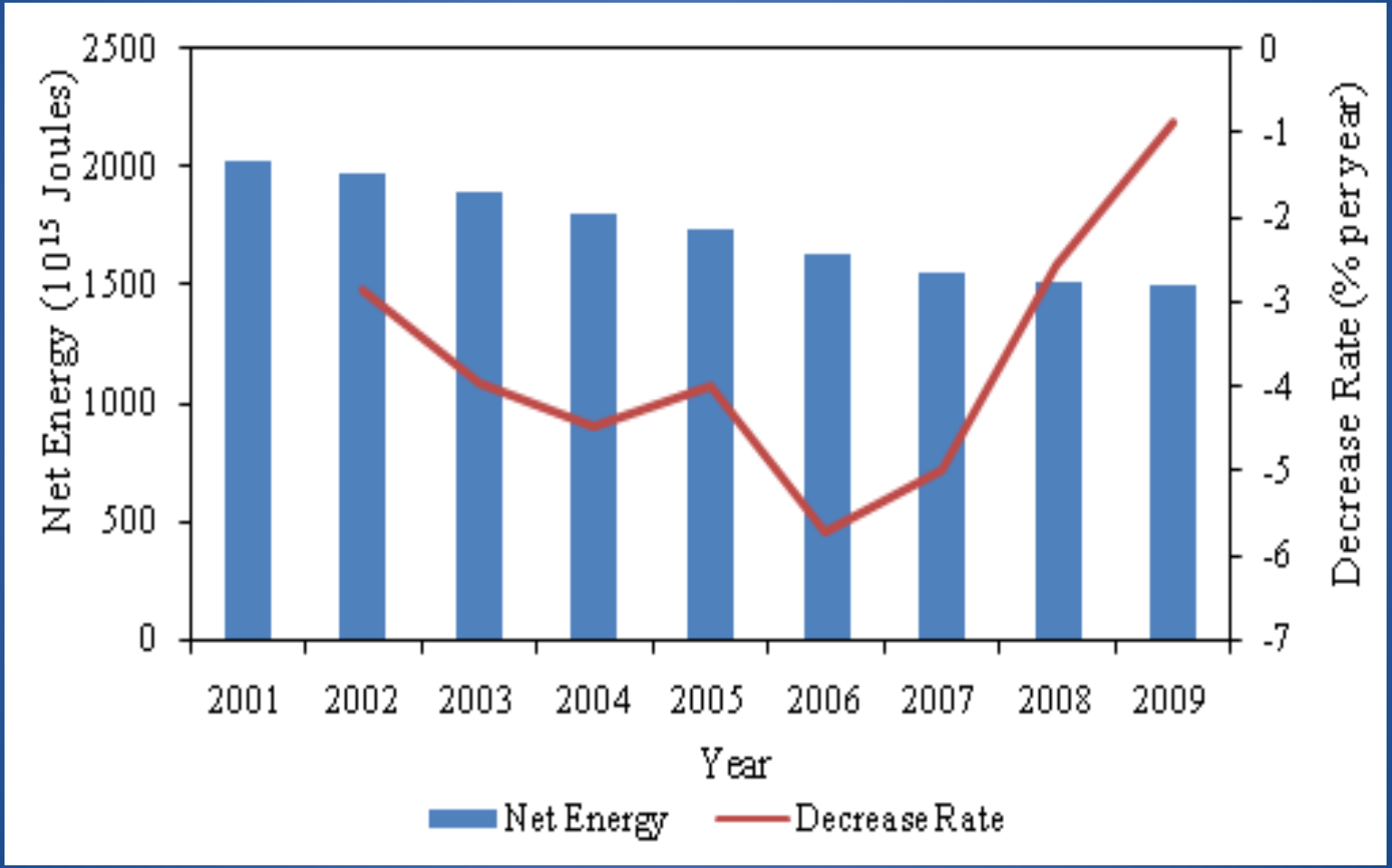
Results- Historical EROI of the Daqing oil field calculated in four different ways. The upper two lines do not include indirect energy costs.



History and forecast of $EROI_{stnd}$. Red line is extrapolated based on best linear fit to trend; blue line is an extrapolation based on costs assuming government goals for production are met, but costs continue to increase.

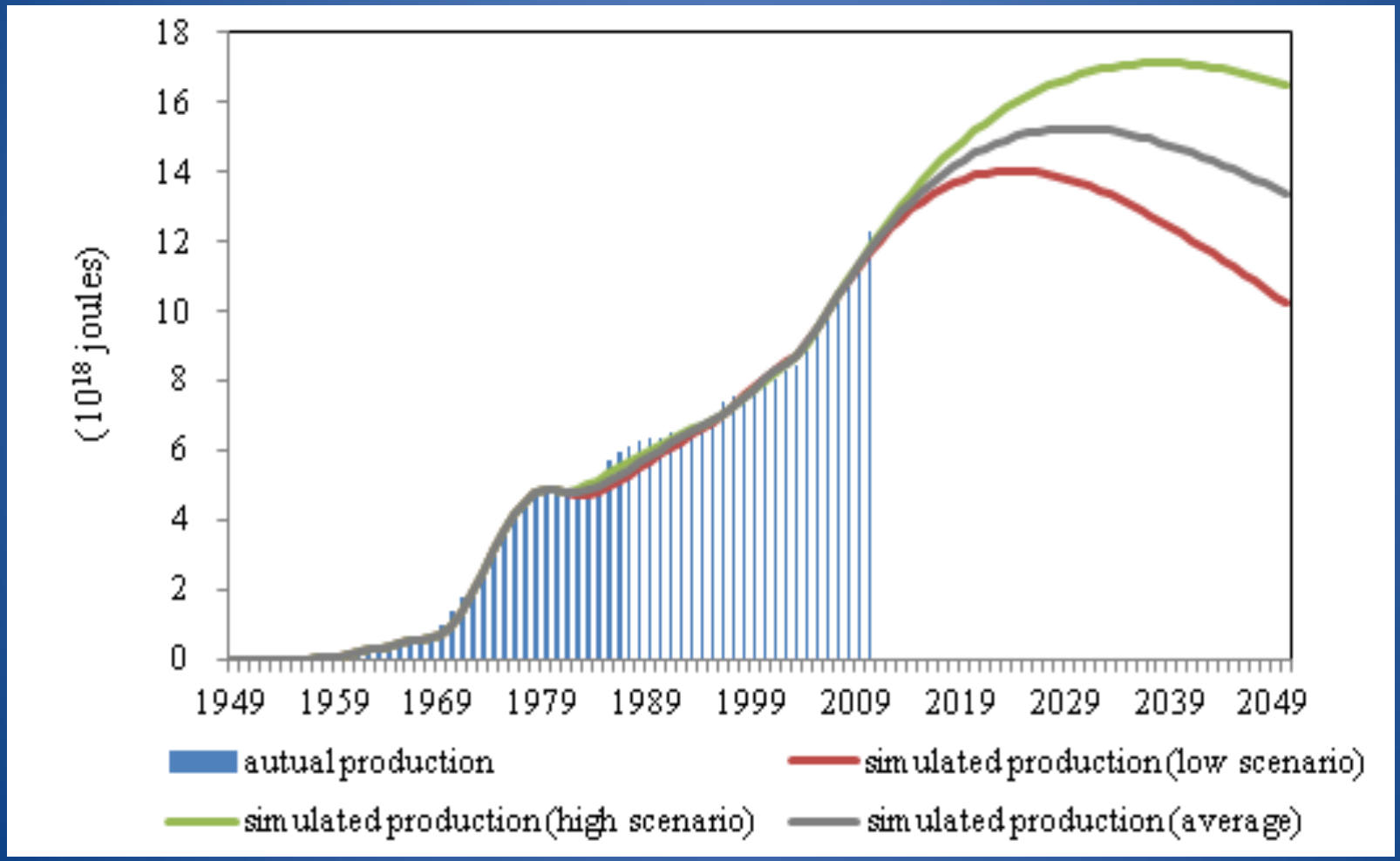


Results-Net energy and decrease rate

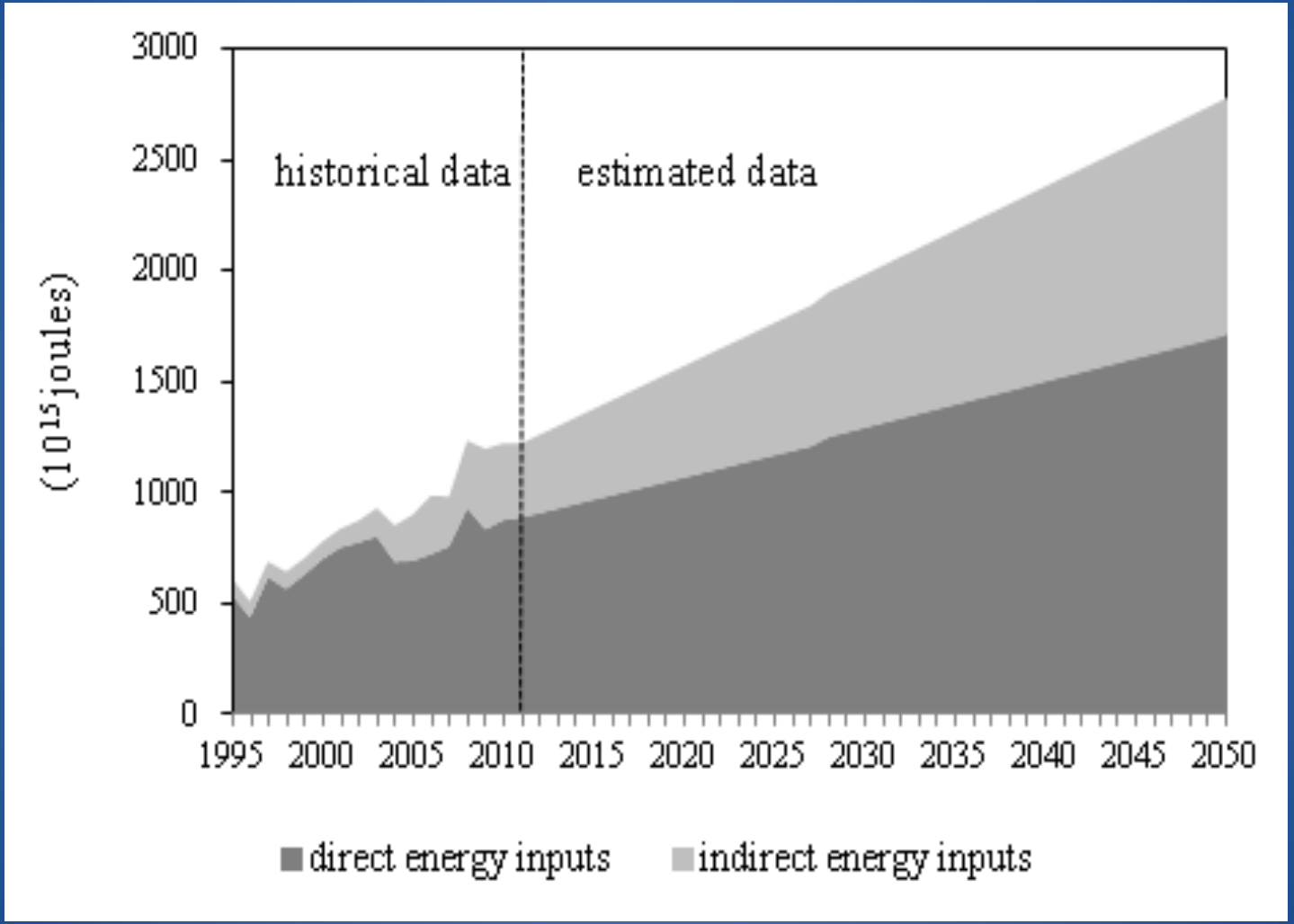


2. EROI of Oil and Gas Extraction in China

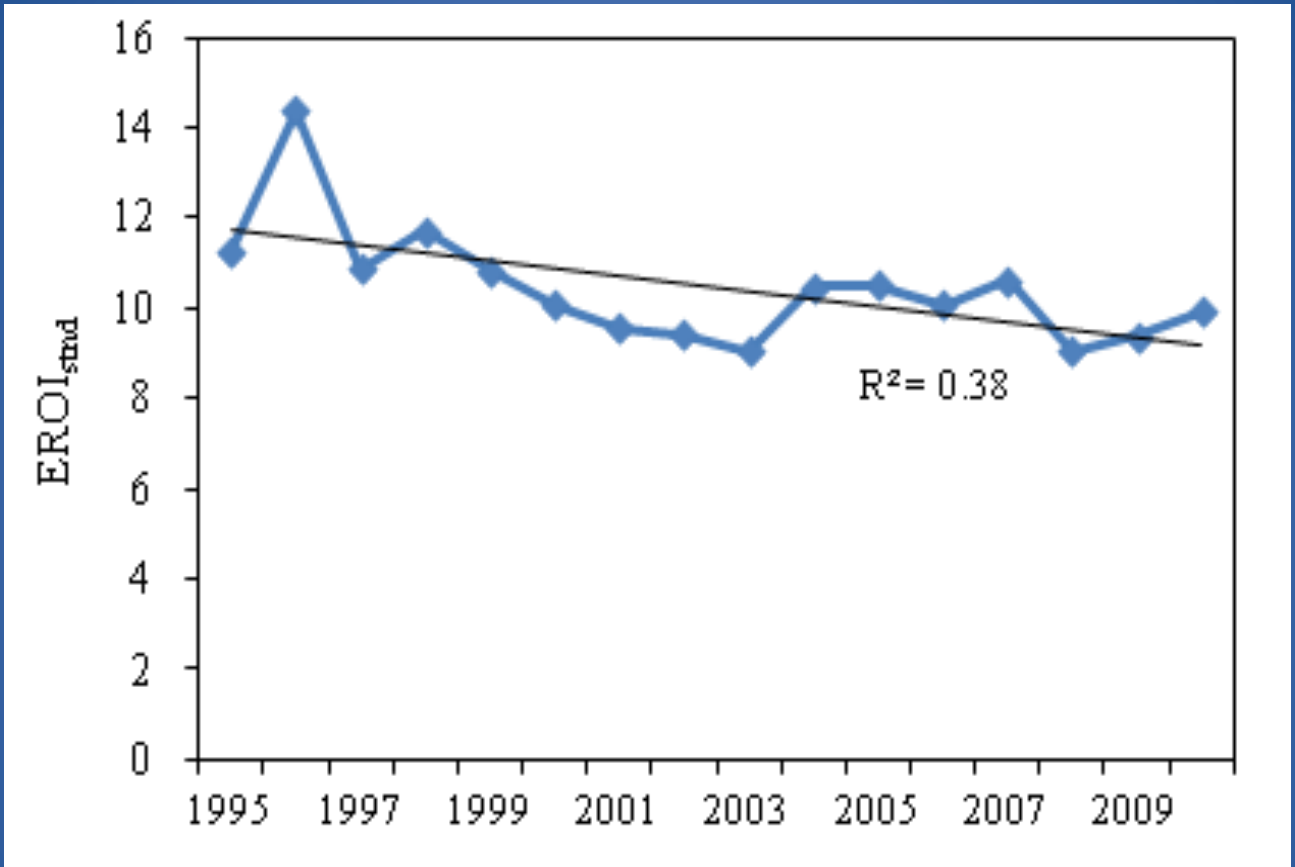
Energy Output – Historical and Future Trends



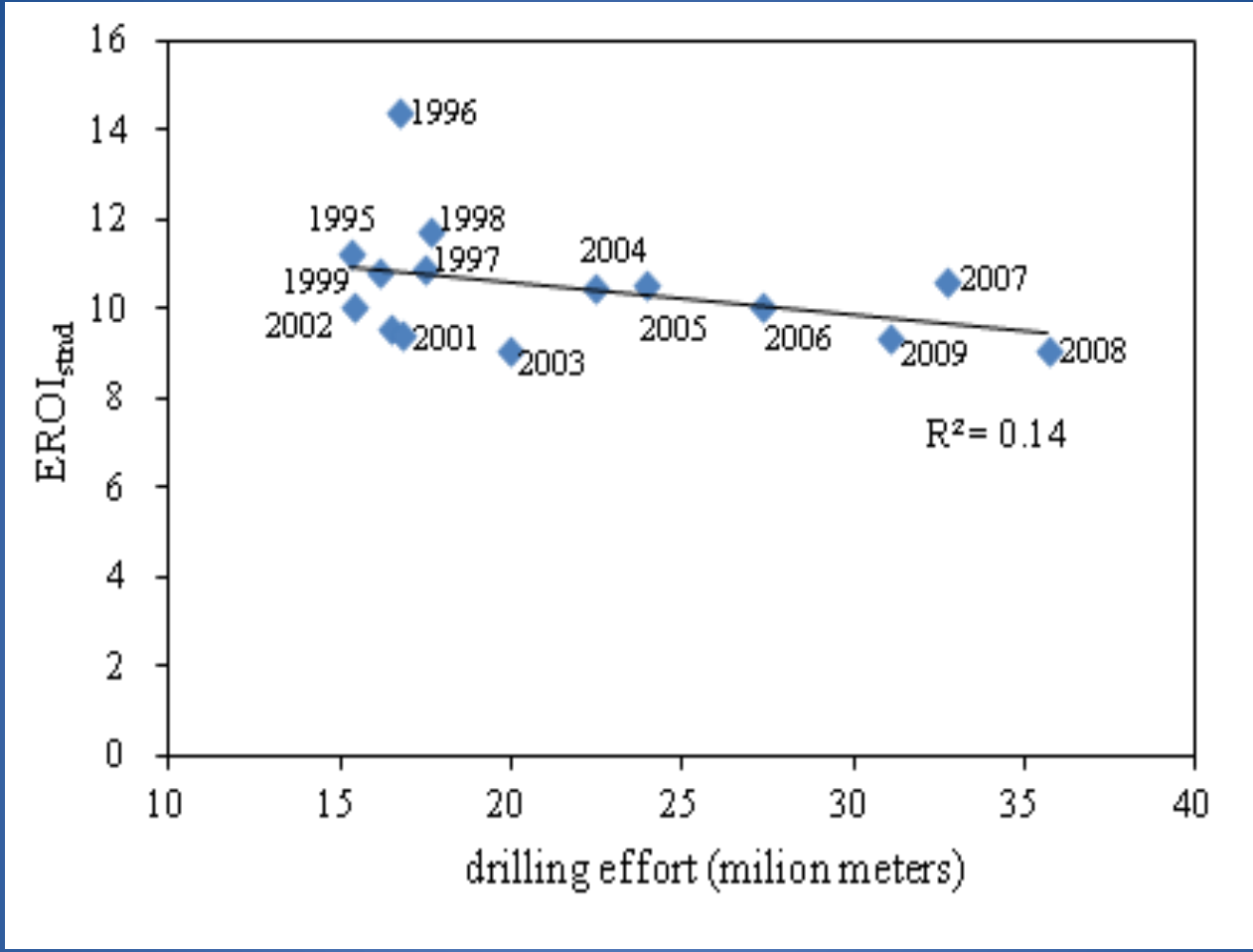
Energy Input – Historical and Future Trends



Results-Historical EROI

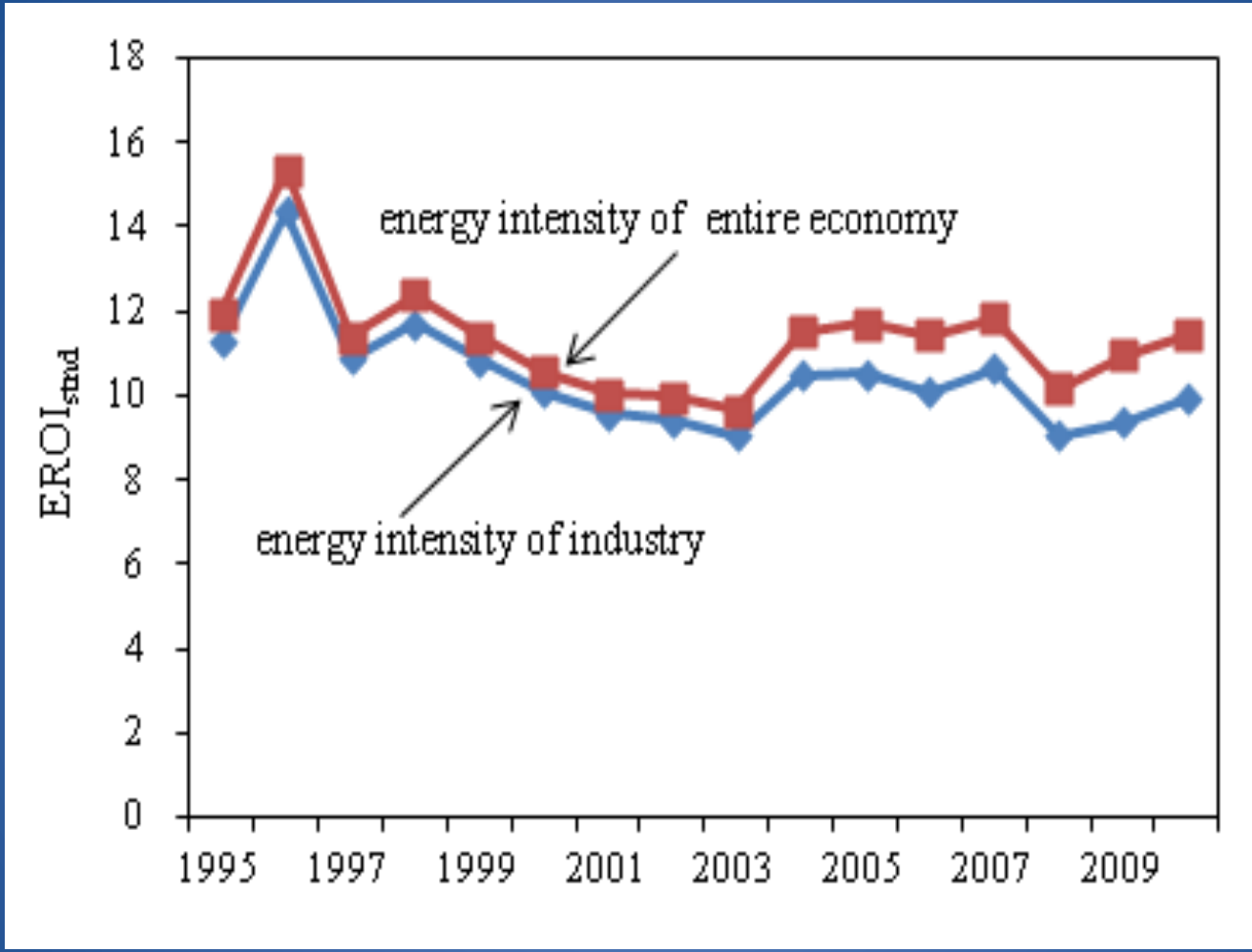


EROI$_{stnd}$ of oil and natural gas extraction in China with linear best fit

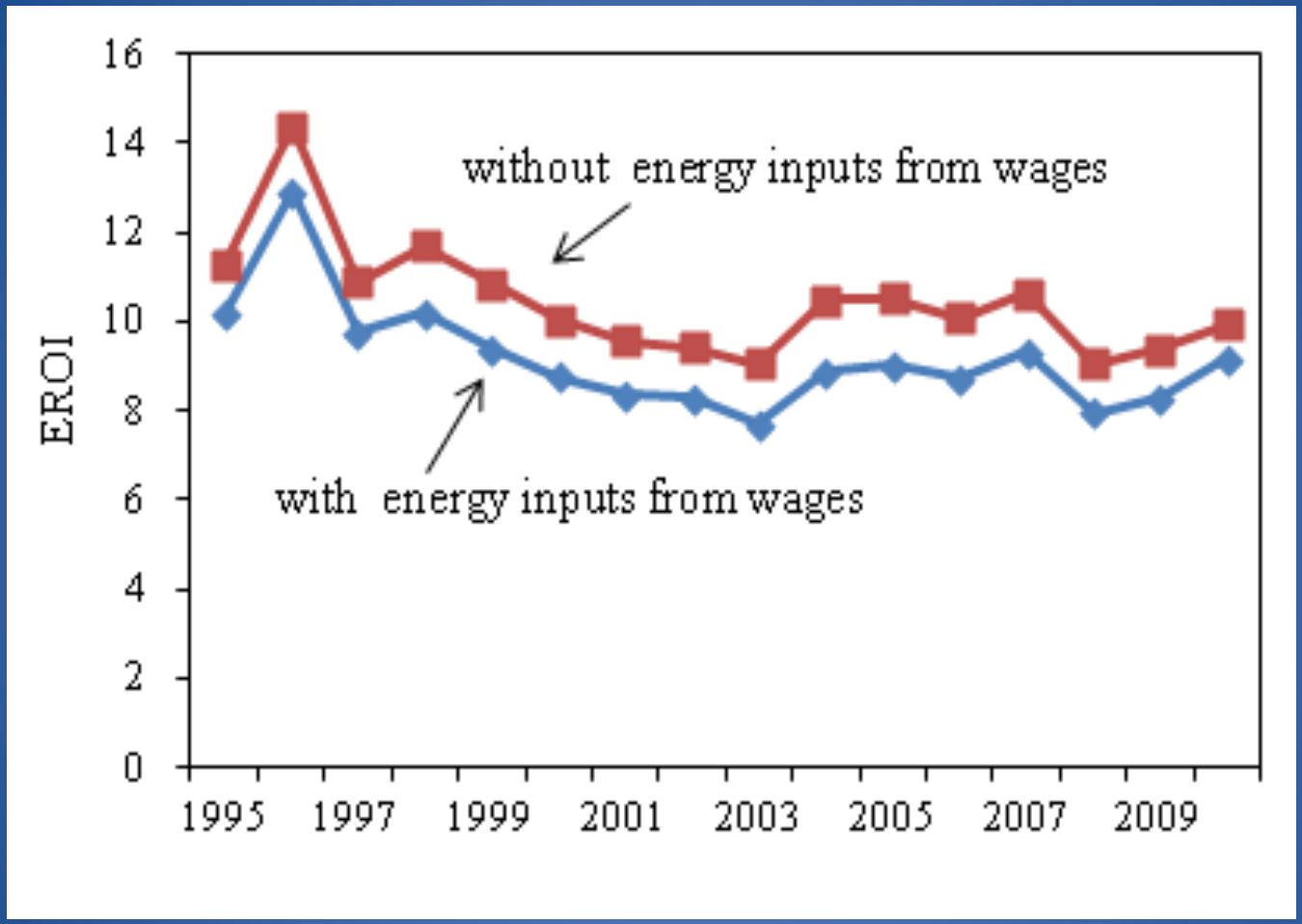


Relation of EROI$_{stnd}$ and drilling effort of oil and natural gas extraction in China with linear best fit

Sensitivity Analysis

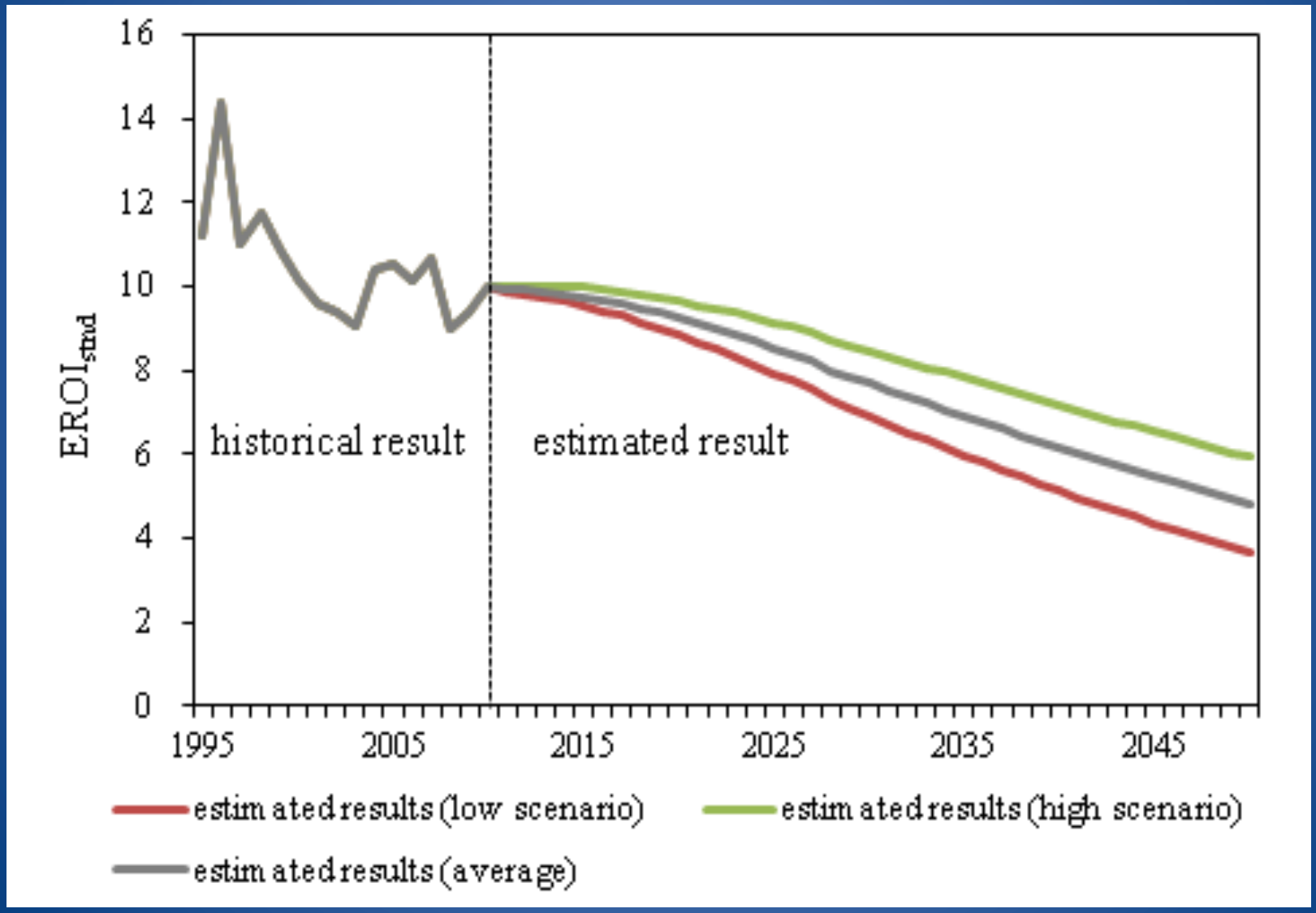


Sensitivity analysis for $EROI_{stnd}$ using the energy intensity for the entire economy and that of industry for estimating the indirect energy.



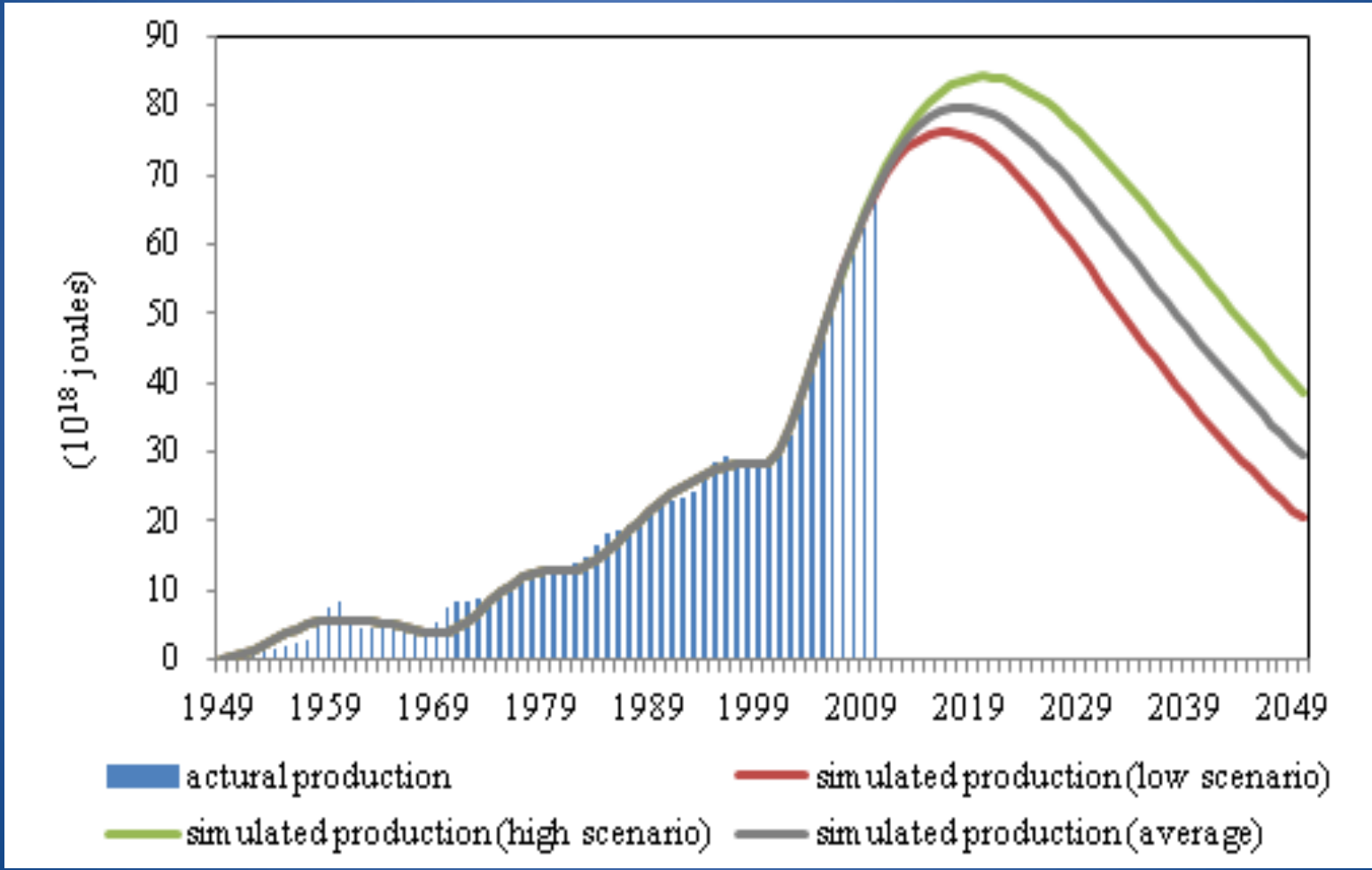
Sensitivity analysis for $EROI_{stnd}$ without and with energy inputs from wages

Results-Future EROI

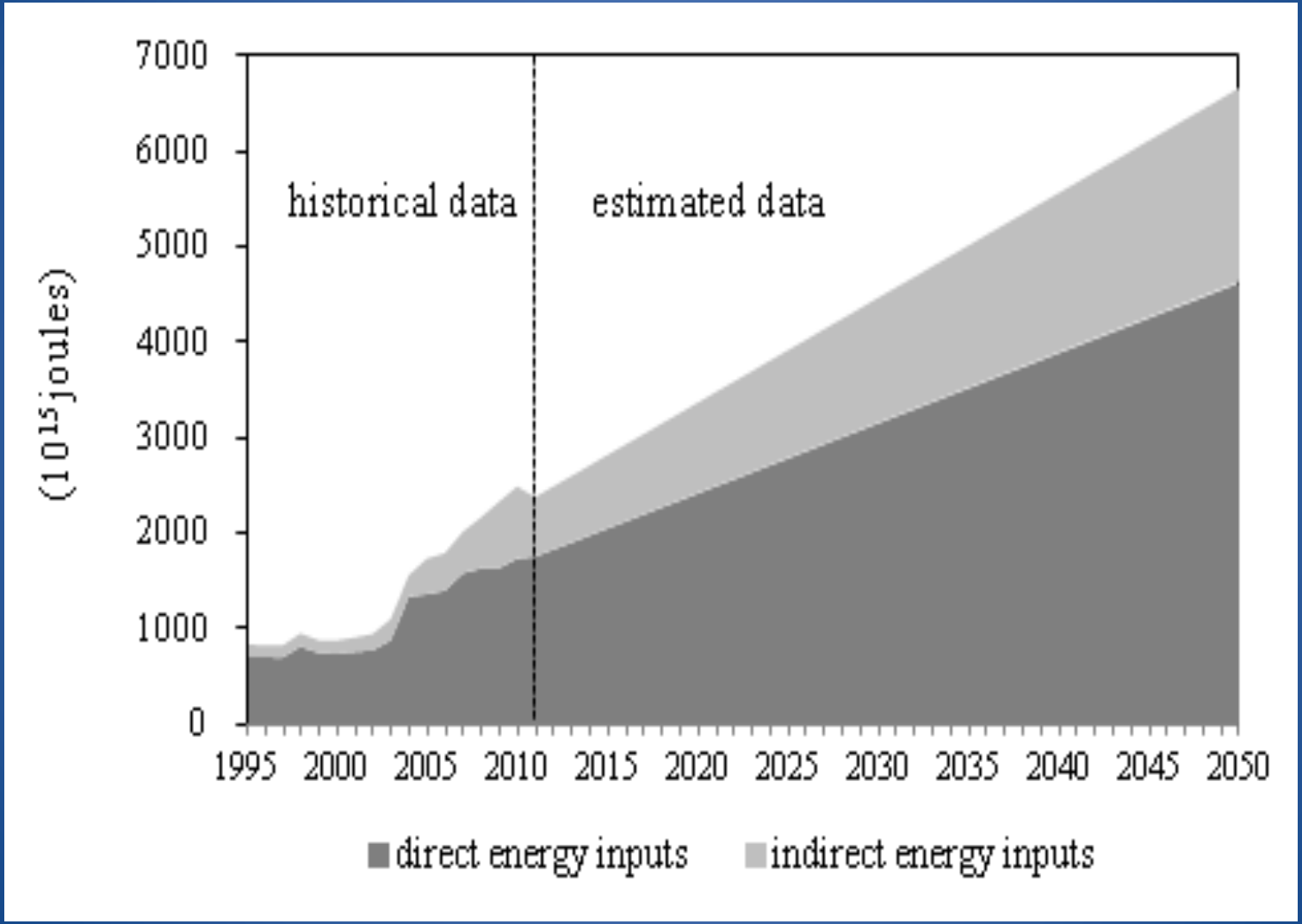


3. EROI of Coal Production in China

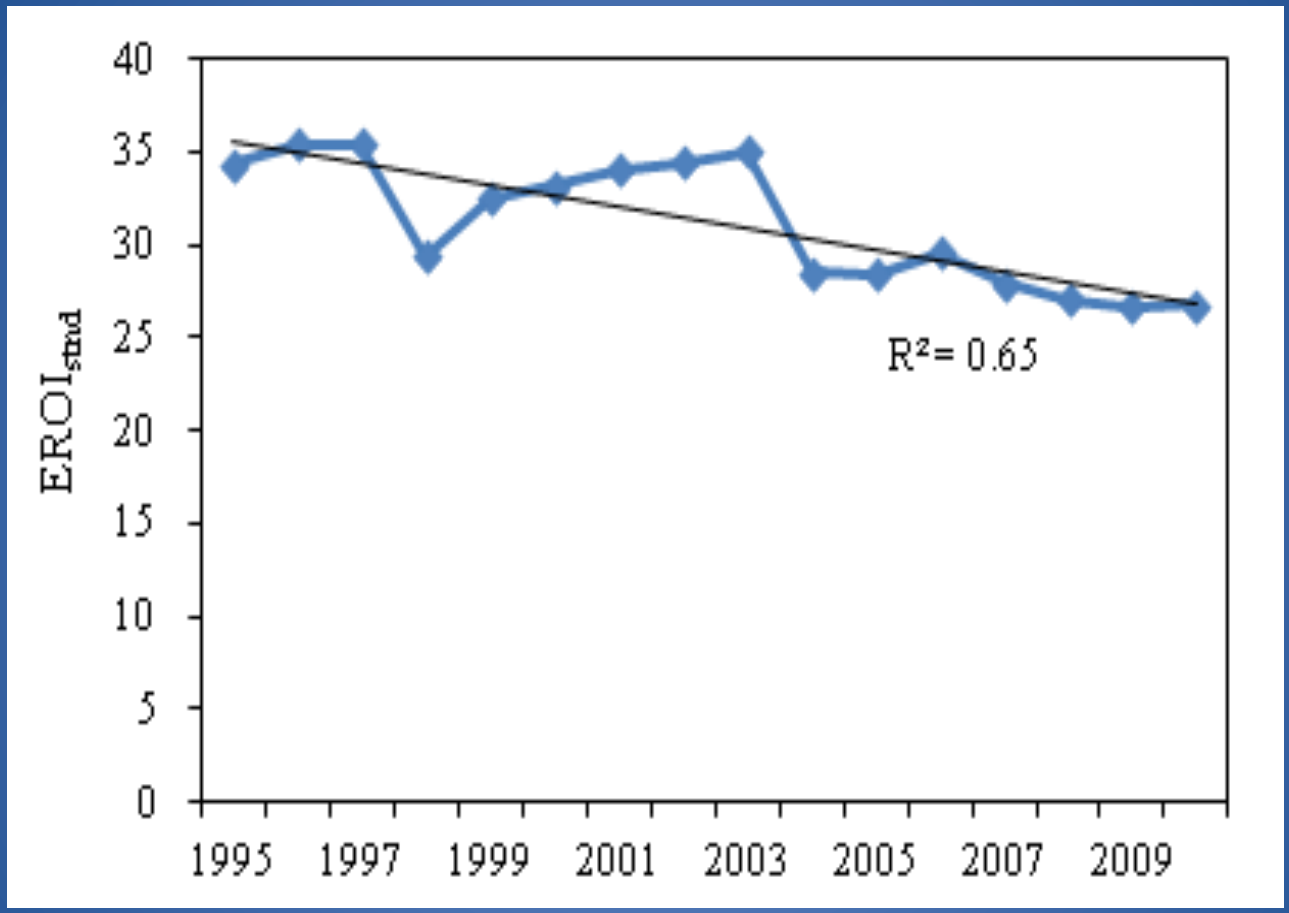
Energy Output – Historical and Future Trends



Energy Input – Historical and Future Trends

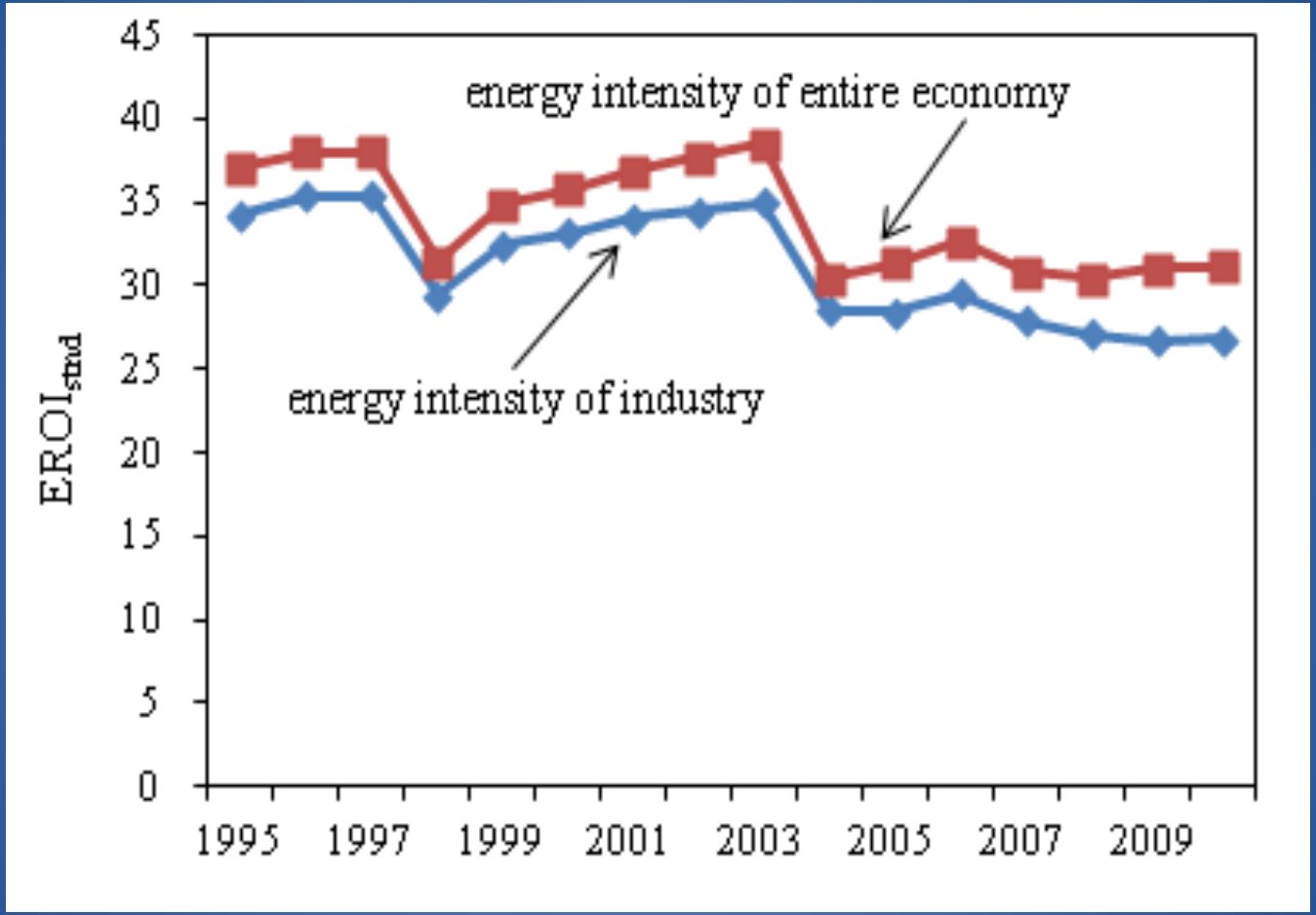


Results-Historical EROI

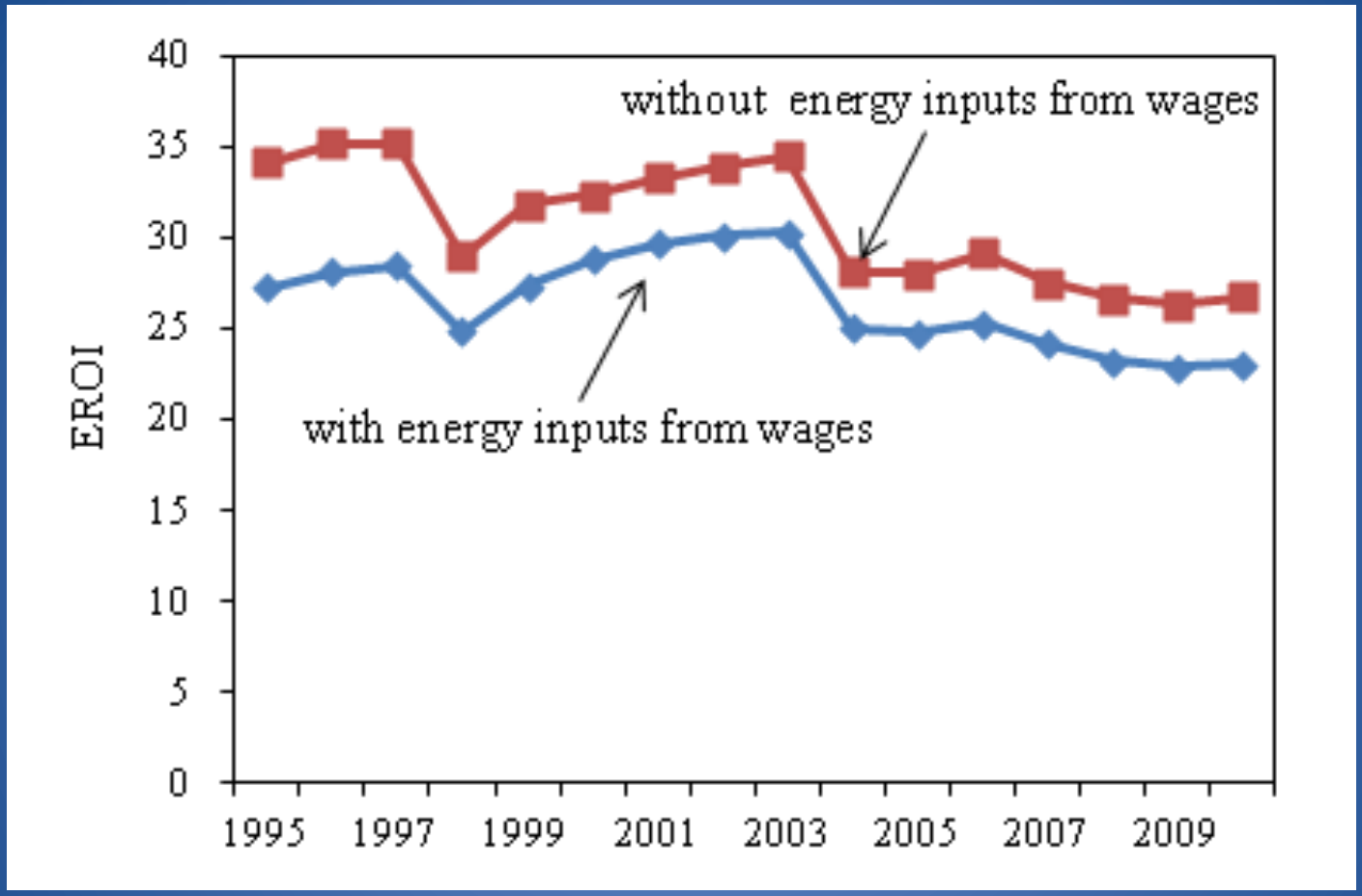


EROI$_{stnd}$ of coal production sector in China with linear best fit

$EROI_{stnd}$ of coal production sector in China with linear best fit

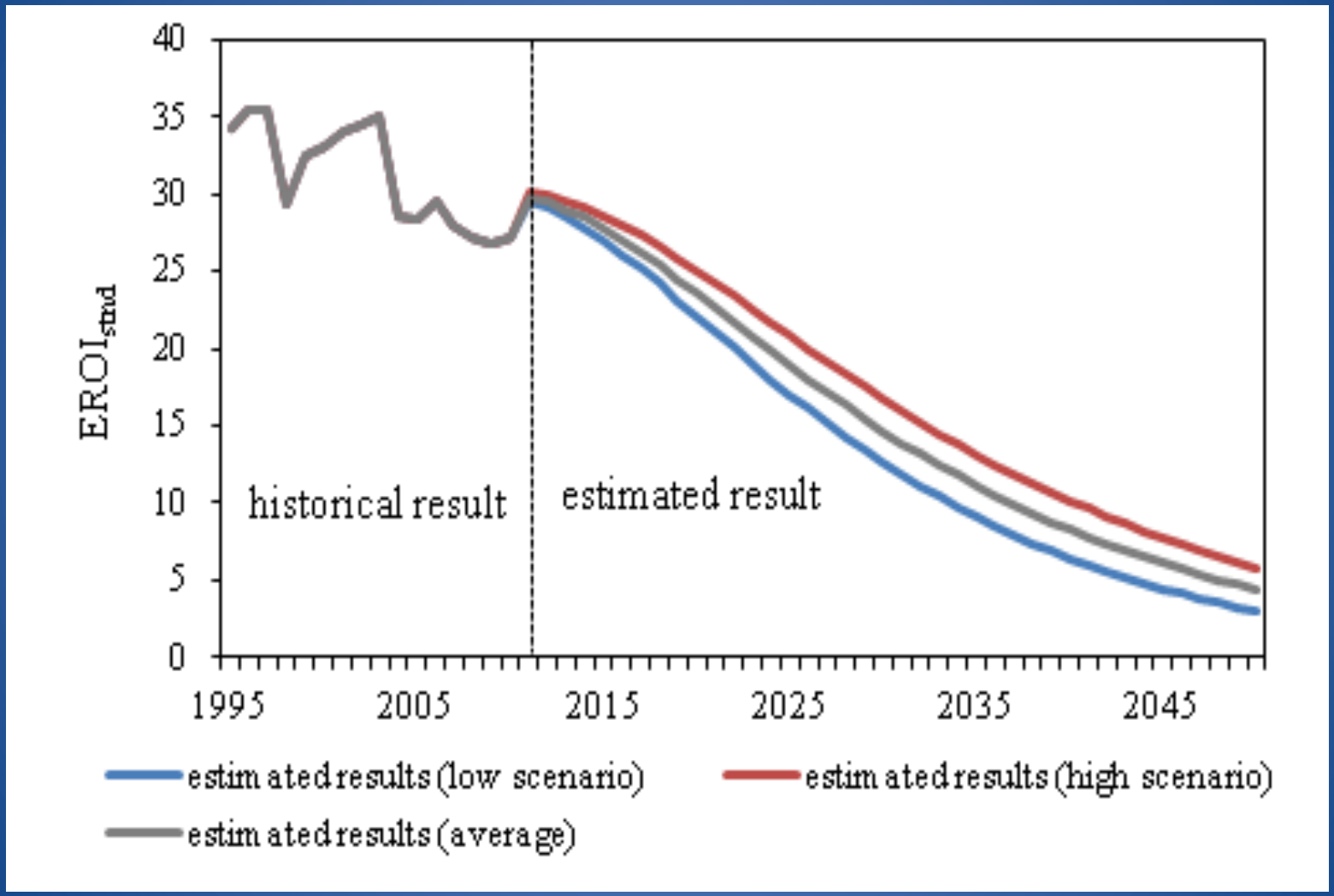


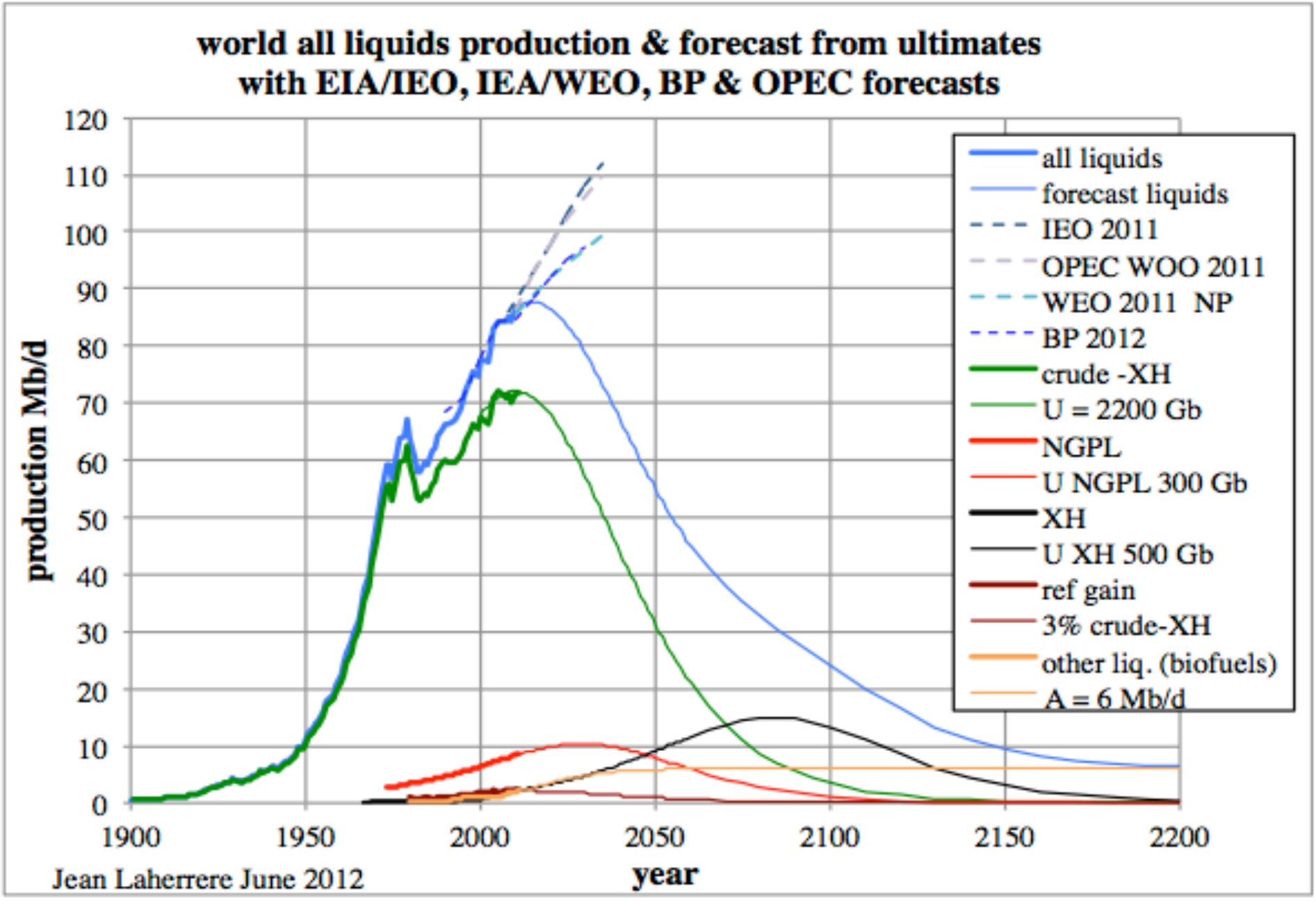
Sensitivity analysis for $EROI_{stnd}$ using the energy intensity of the entire economy and that of industry for estimating the indirect energy.



Sensitivity analysis for $EROI_{stnd}$ without and with energy inputs from wages

Results-Future EROI




world all liquids production & forecast from ultimates
with EIA/IEO, IEA/WEO, BP & OPEC forecasts
production Mb/d
120
110
100
90
80
70
60
50
40
30
20
10
0
1900
1950
2000
2050
2100
2150
2200
year
Jean Laherrere June 2012
all liquids
forecast liquids
IEO 2011
OPEC WOO 2011
WEO 2011 NP
BP 2012
crude -XH
U = 2200 Gb
NGPL
U NGPL 300 Gb
XH
U XH 500 Gb
ref gain
3% crude-XH
other liq. (biofuels)
A = 6 Mb/d