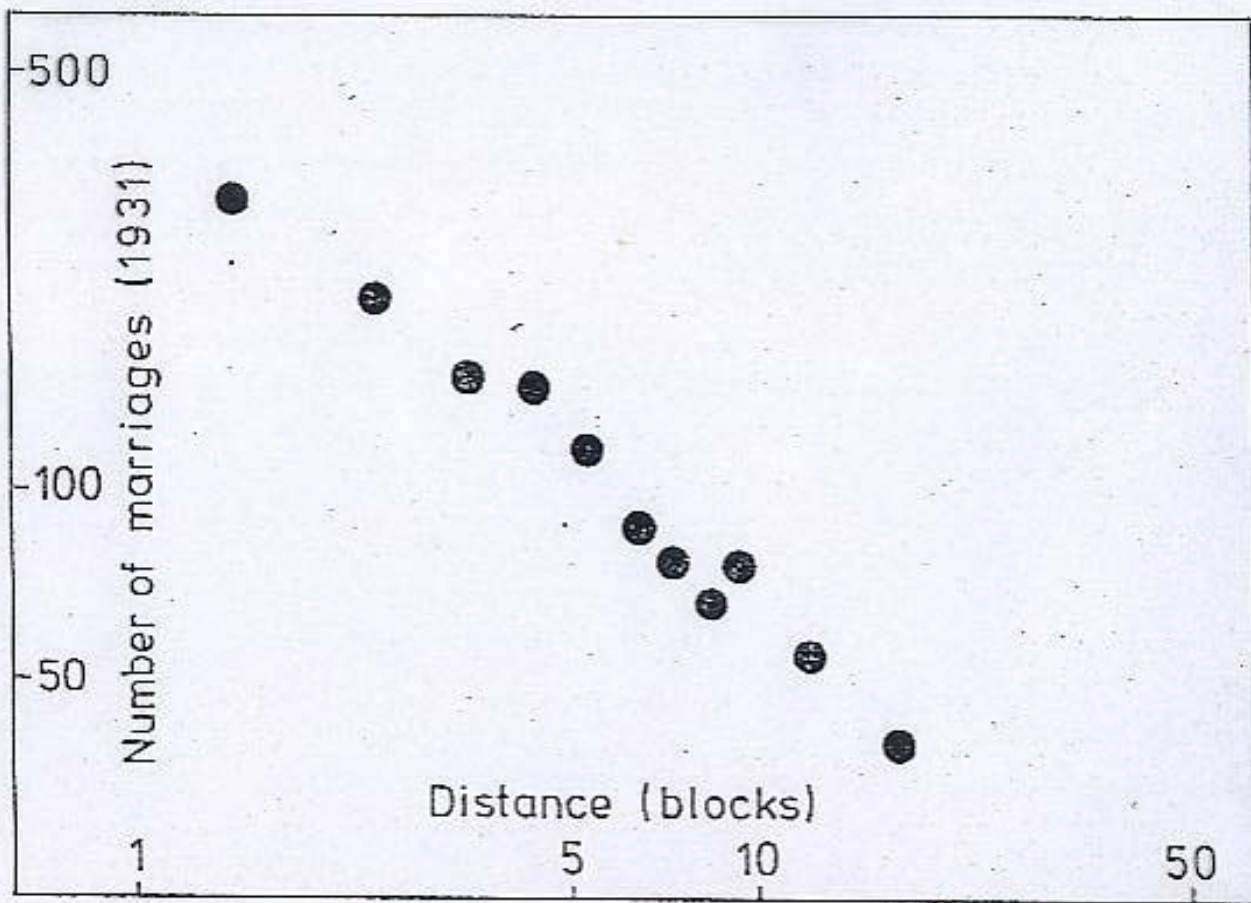
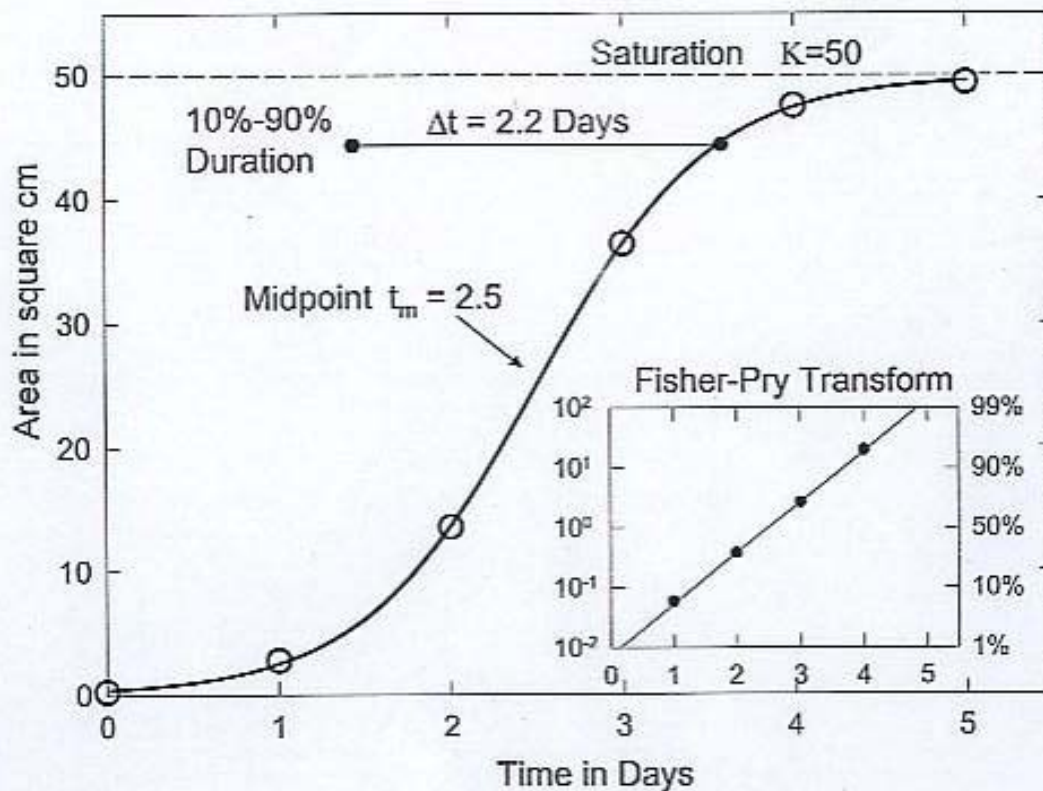


# MARRIAGES IN PHILADELPHIA, 1931



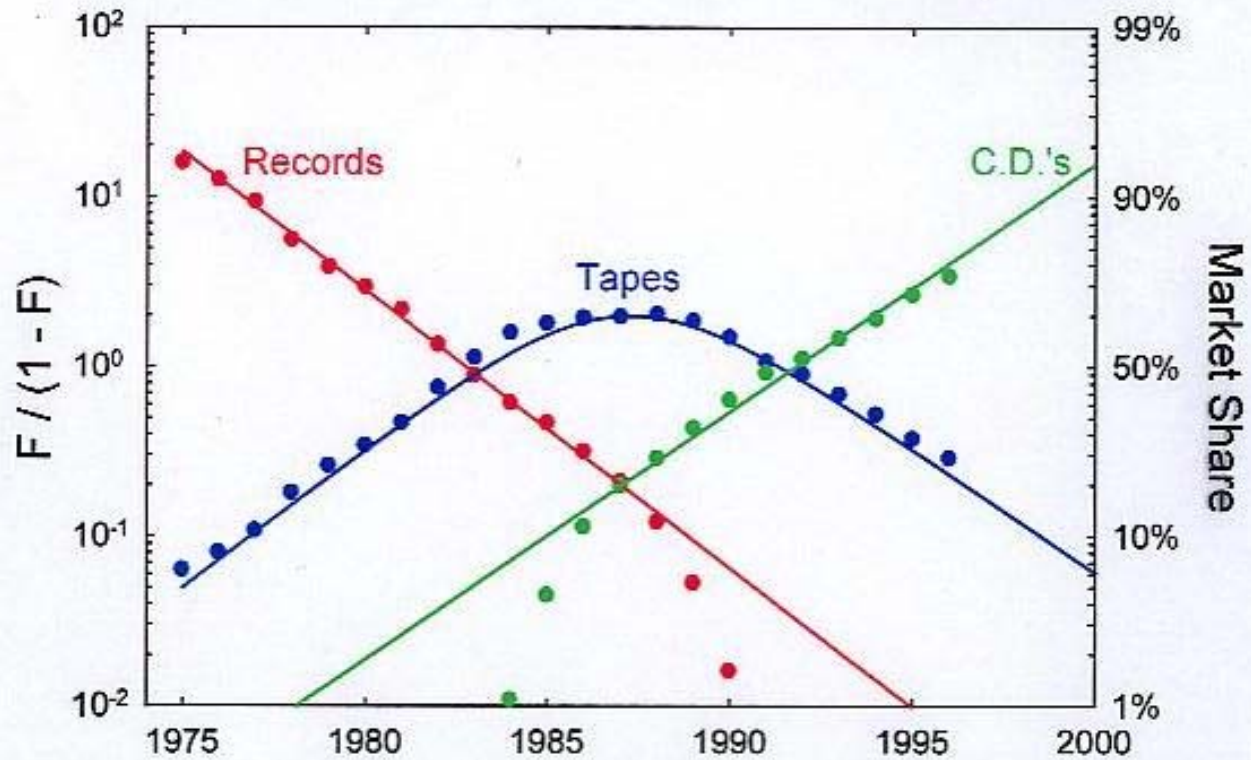
SOURCE: ZIPF, 1949

## Growth of A Bacteria Colony with a Logistic Curve



Source: Meyer and Ausubel, 1997.

## Logistic Substitution of U.S. Music Recording Media



Source: Meyer et al., 1999



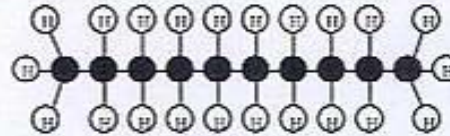
# Hydrogen-Carbon Composition of Fossil Fuels

Methane Gas



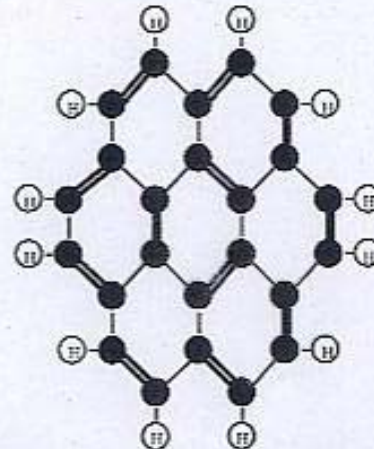
H:C = 4:1

Typical Oil



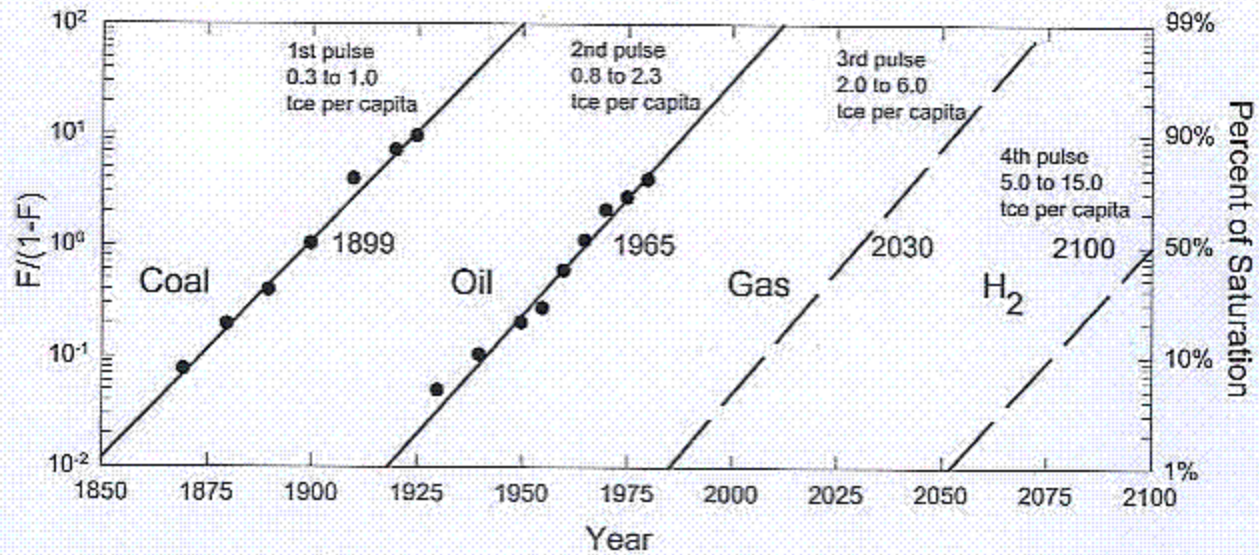
H:C = 2:1

Typical Coal



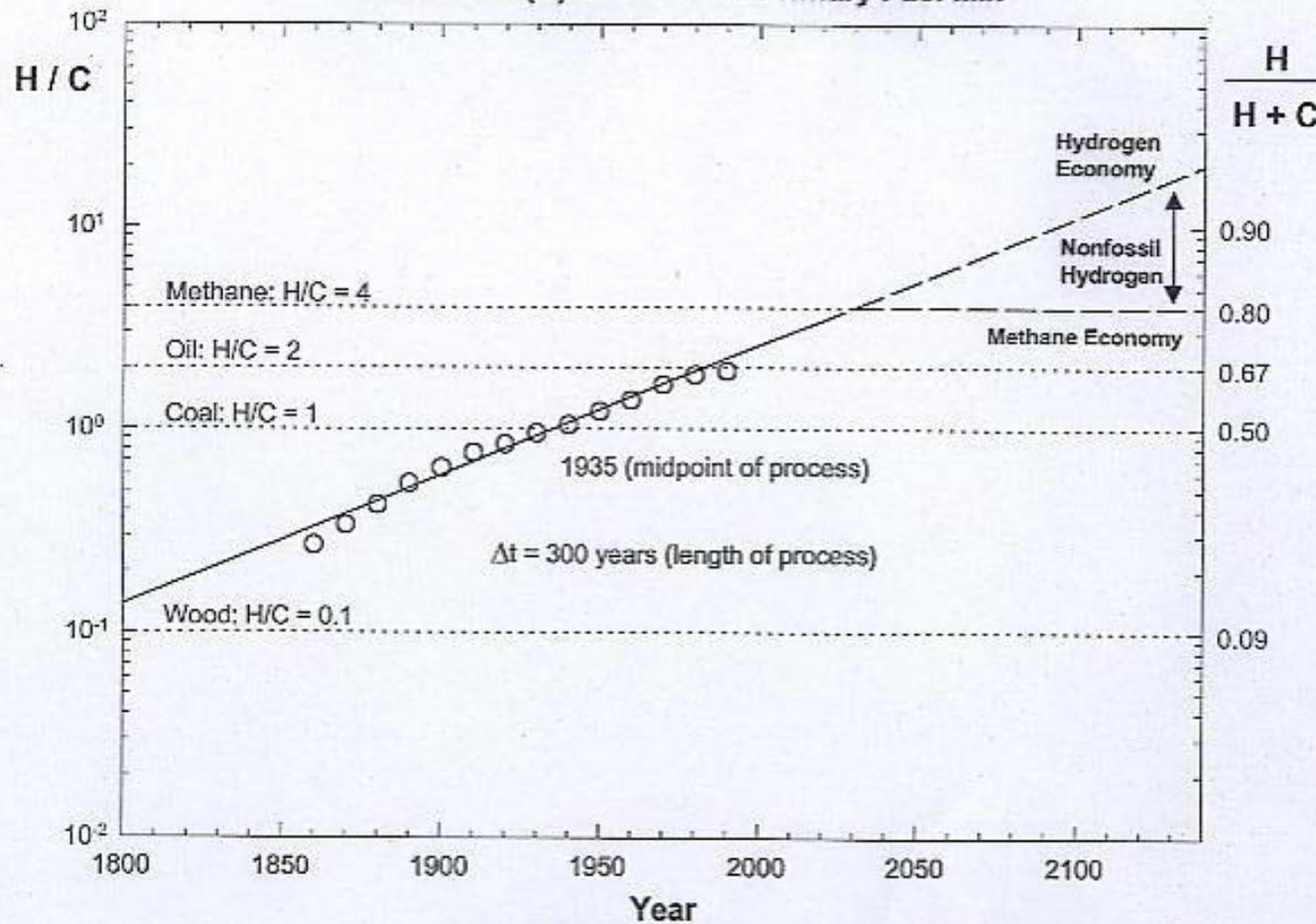
H:C = 0.5:1

### Growth Pulses in World Per Capita Energy Consumption (tons coal equivalent)



After Ausubel et al., 1988.

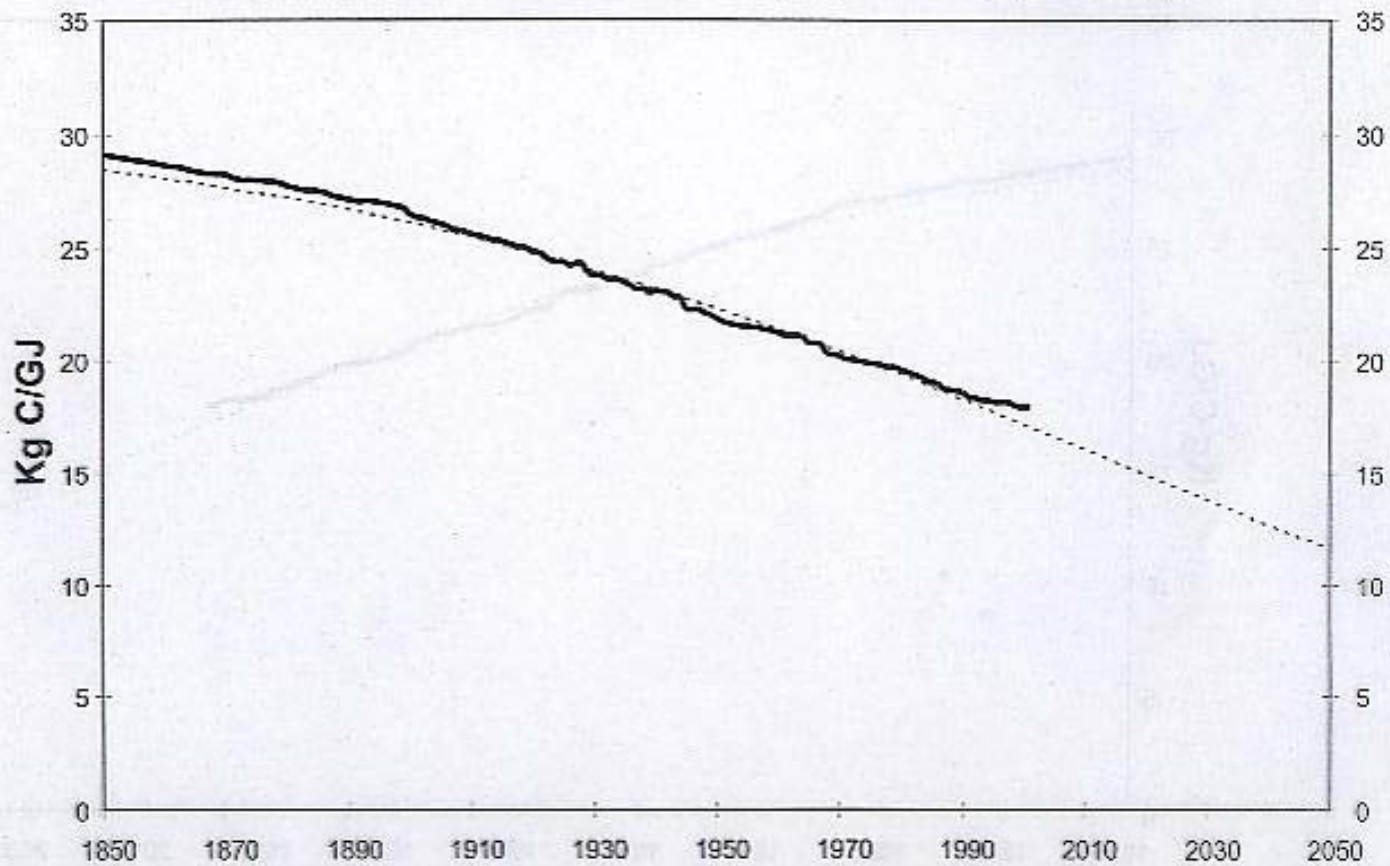
### Decarbonization: Evolution of the Ratio of Hydrogen (H) to Carbon (C) in the World Primary Fuel Mix



Source: Ausubel, 1996, after Marchetti, 1985

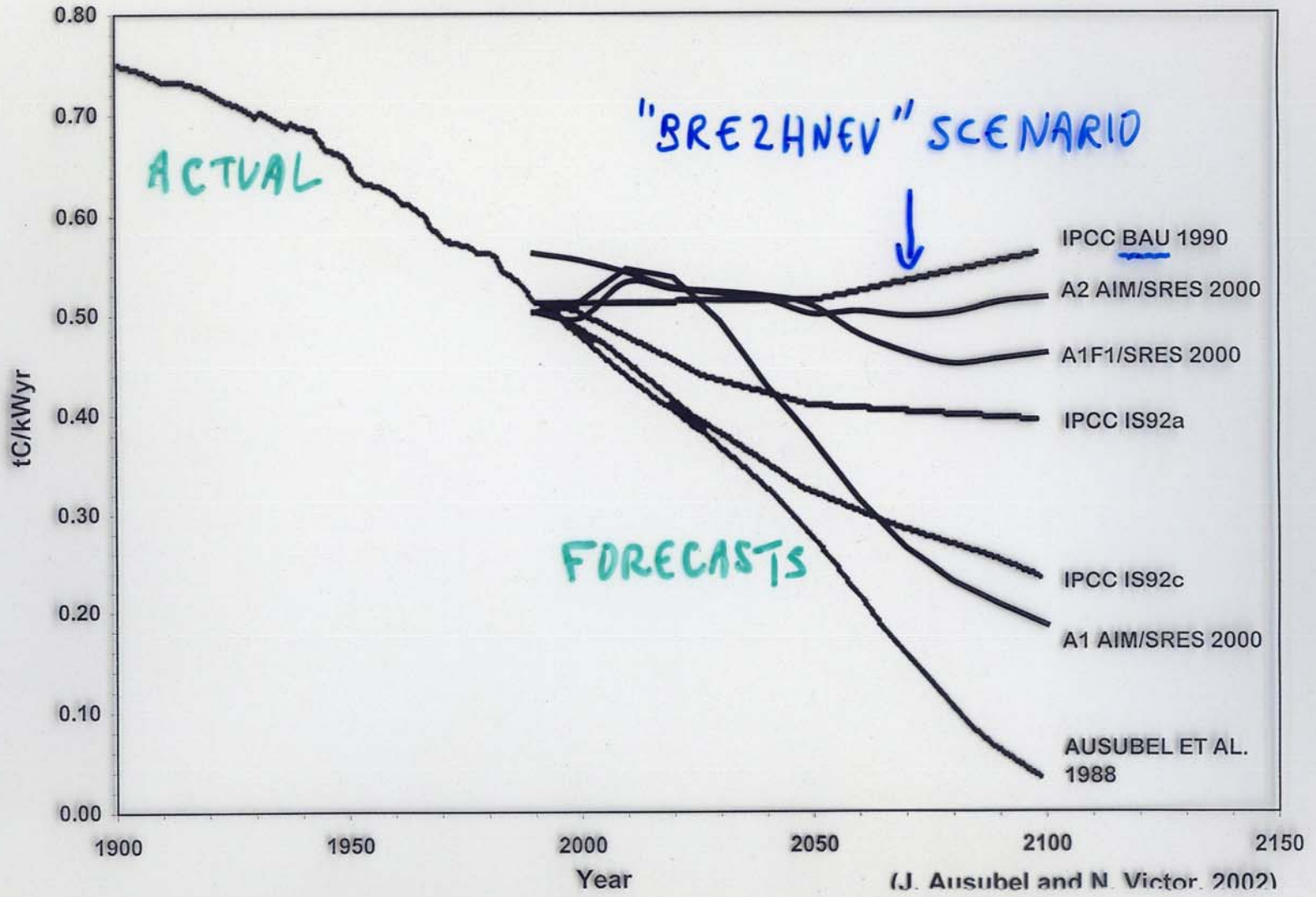


## Falling Global Carbon Intensity of Primary Energy



Data sources: IIASA, BP (1965-2001), CDIAC [http://cdiac.esd.ornl.gov/trends/emis/em\\_cont.htm](http://cdiac.esd.ornl.gov/trends/emis/em_cont.htm)

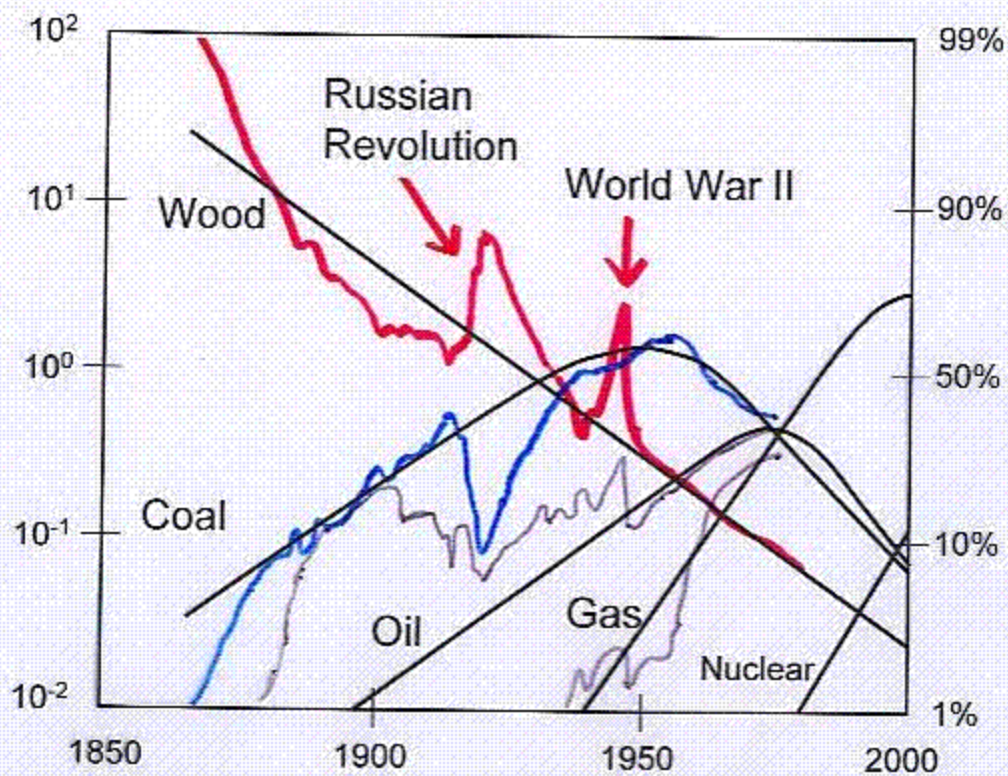
# DECARBONIZATION SCENARIOS



(J. Ausubel and N. Victor. 2002)



## USSR - Primary Energy Substitution: Shock Absorption



After: Nakicenovic 1978

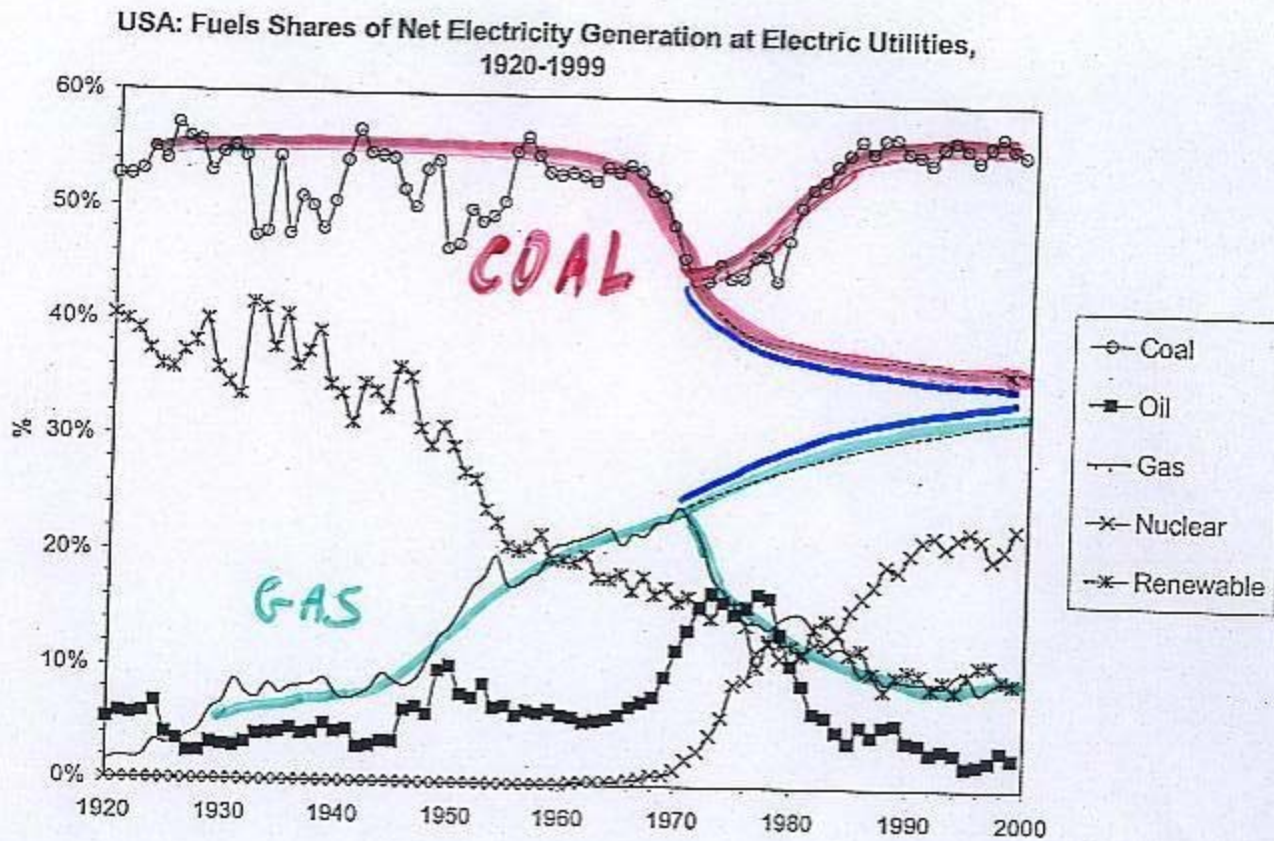
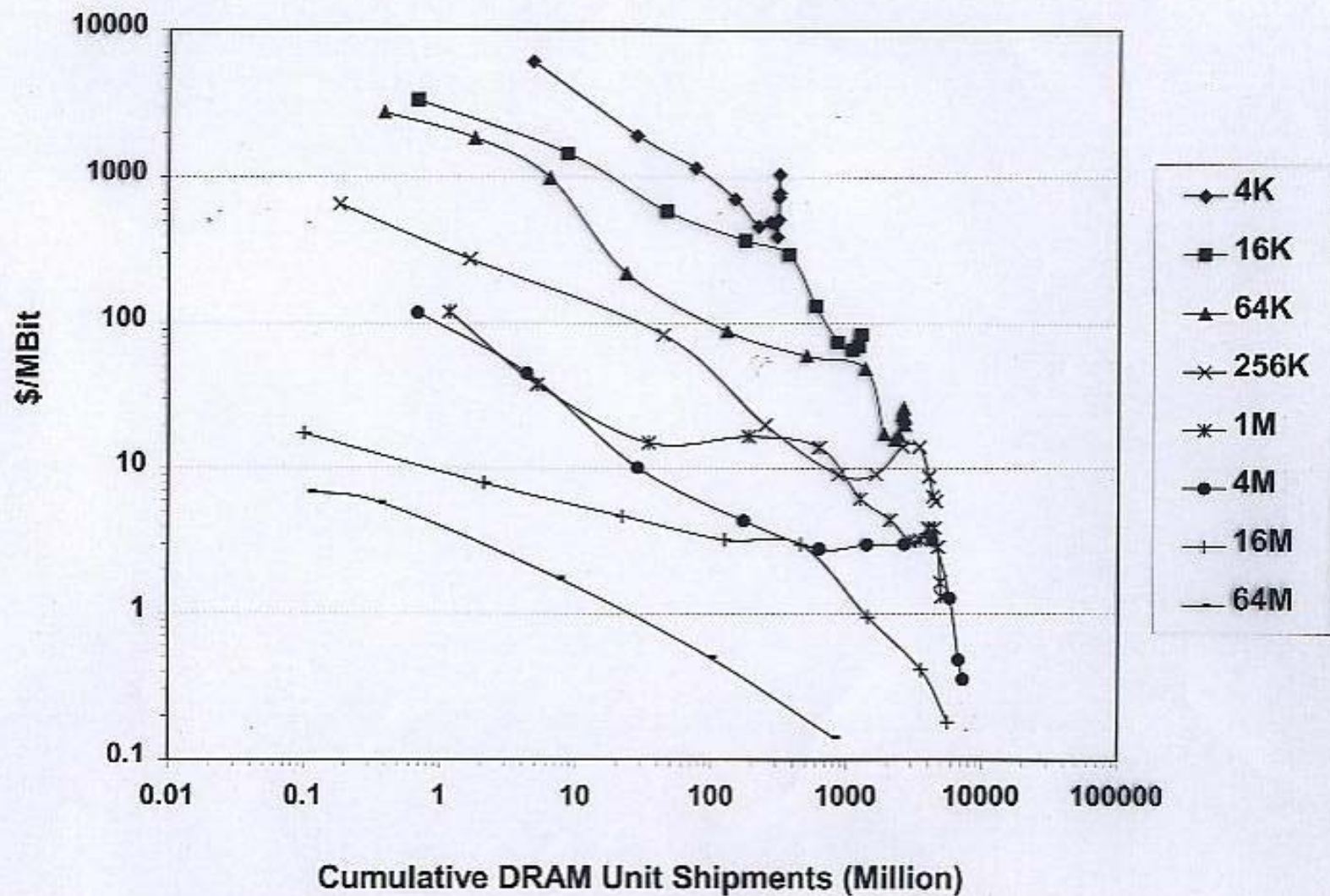


Figure 11 USA fuels shares of net electricity generation at electric utilities in 1920-1999.

Sources: Mitchell B.R., EIA (2001)

## Learning-by-Doing in DRAM Chips Generations



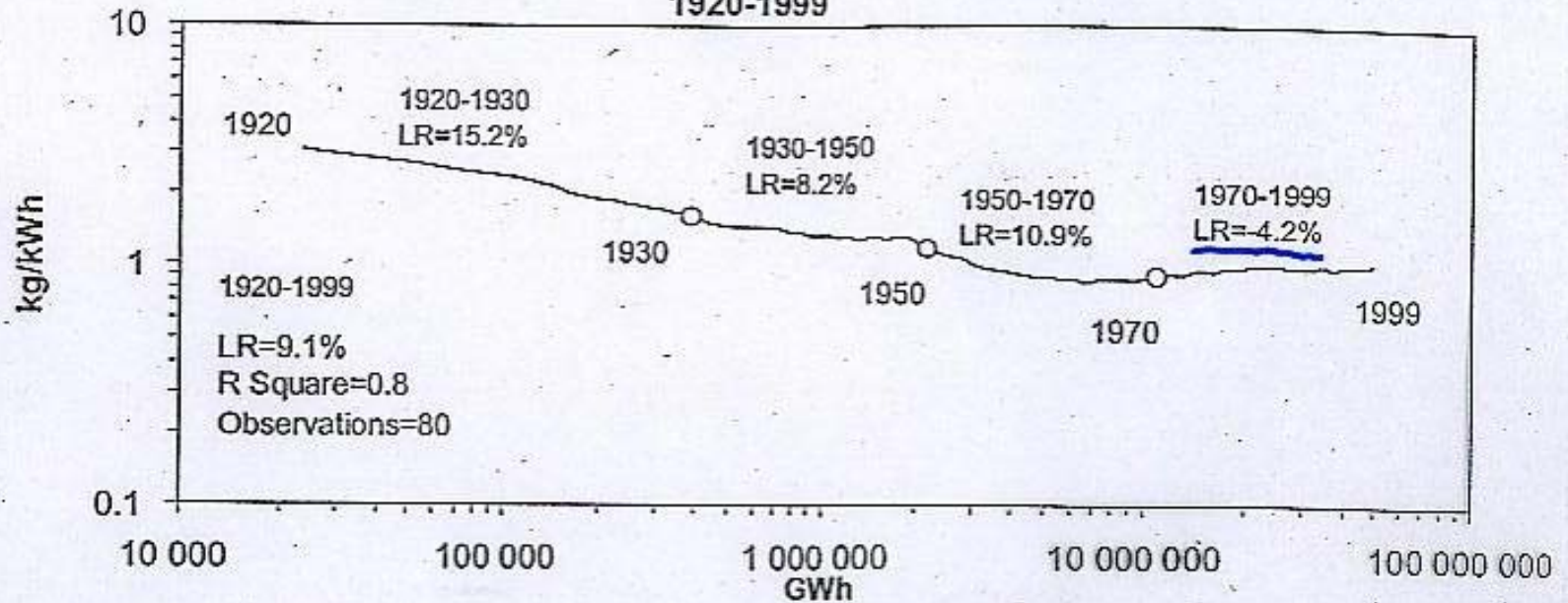
Data Source: Integrated Circuit Engineering Corporation, 1999  
 Irwin, D.A. and Klenow, P.J., 1994

Ausubel, J., Meyer P.J., Victor, N.



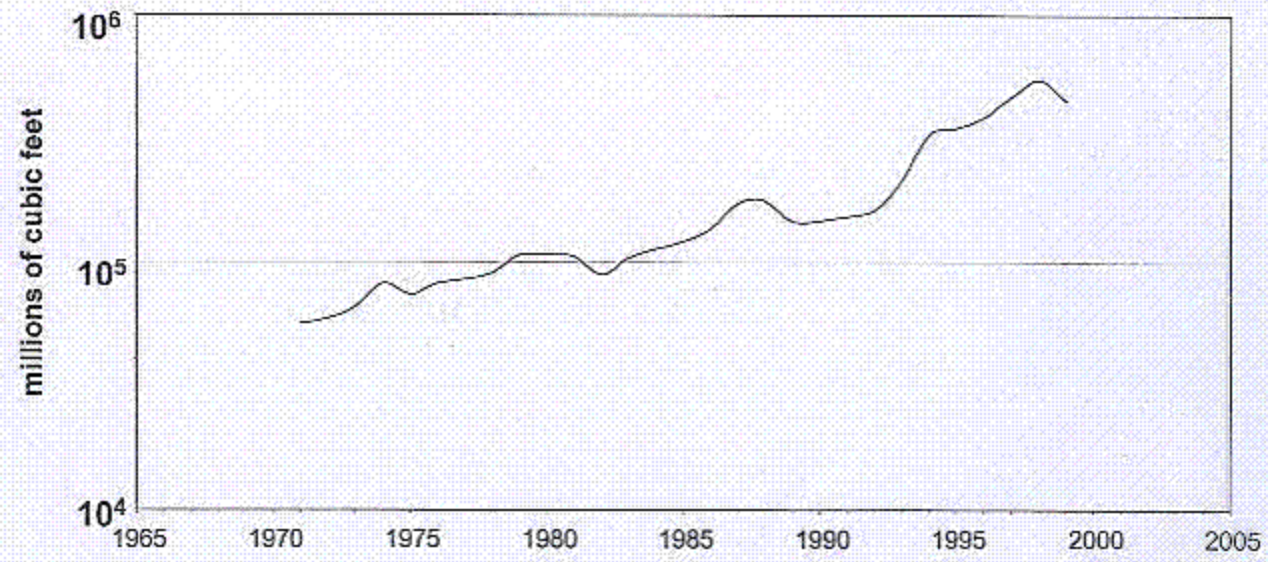
# LEARNING CURVE FOR COAL

USA: Coal consumed at electric utilities per kWh electricity generation  
versus cumulative electricity generation from coal,  
1920-1999



source: Victor & Ausubel, 2002

### USA: Hydrogen Production, 1971-1999



Source: N. M. Victor and J.H. Ausubel, 2002