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Energy Efficiency and Renewable Energy Fuel Equivalents to Potential Oil Production from the Arctic National Wildlife Refuge (ANWR)

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Summary

Congress is considering bills to allow oil development in ANWR, an area in northeastern Alaska with a unique ecosystem rich in plant life and wildlife that is also one of the most prospective onshore areas in the United States for large oil discoveries. President Bush has proposed opening the area to oil and natural gas development.

Among the numerous recommendations of the Administration report, *Reliable, Affordable, and Environmentally Sound Energy for America's Future* (May 2001), are proposals to open ANWR, foster energy efficiency and energy conservation, and review automobile fuel efficiency. Some observers believe all of the Administration-recommended initiatives are necessary for meeting the nation's future energy needs. Others suggest that pursuing energy efficiency and conservation initiatives can eliminate the need for undertaking certain production efforts that they see as posing risks to the environment or other values. Specifically, many who oppose opening ANWR argue that the oil saved from increased energy efficiency and conservation (through use of alternative fuels) could do more to increase energy security and to reduce prices than exploiting any oil that might be found in ANWR, while also avoiding the risk of damage to the environment and wildlife and the reduction of its wilderness character.

This report compares the range of estimates for potential oil production from ANWR with potential energy savings from increases in fuel economy and expanded use of ethanol. It thus provides two of many possible answers to the question, "Could energy efficiency and conservation save as much oil as ANWR might supply? It does not address the larger question of whether that tradeoff makes sense in light of the total energy picture.

The Energy Information Administration (EIA) says that a technology-driven projection for cars and light trucks could increase fuel economy by 3.6 miles-per-gallon by 2020. The fuel economy improvement through the first 20 years would generate average daily oil savings equivalent to four times the low case and three-fourths of the high case projected for ANWR oil production. Extended through 50 years, the fuel economy savings would range from 10 times the low case to more than double the high case for ANWR. Also, a Department of Energy (DOE) report projects that the development of cellulosic ethanol technology could more than double the growth in ethanol use by 2020. By displacing gasoline, the increased ethanol use would, through the first 20 years, generate average daily oil savings equivalent to one-fifth of the low case and 4% of the high case for ANWR. Extended through 50 years, the ethanol savings would range from three-fourths of the low case to 16% of the high case for ANWR.

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Introduction

Congress is considering bills to allow oil development in ANWR, an area in northeastern Alaska with a unique ecosystem rich in plant life and wildlife. Current law does not allow energy development in ANWR, but growing oil imports and rising prices for oil and gasoline have rekindled proposals for oil development there.

Proponents of ANWR development argue that its oil production could reduce the upswing in prices, lower oil imports, and bolster national energy security by lessening U.S. market exposure to recurring crises in the Middle East. Further, it would help the economy by creating jobs for the oil industry and improving the economic viability of the TransAlaska Pipeline. Also, they claim that oil drilling technology has advanced to the point where ANWR oil could be developed with minimal environmental impacts. President Bush has proposed ANWR development as a key part of his energy policy and it is featured in the Administration's report, *Reliable, Affordable, and Environmentally Sound Energy for America's Future.*

Opponents argue that oil prices are set in the world market where the far greater supply and lower cost of Persian Gulf oil ensures that ANWR production would have little effect on imports and virtually no effect on oil prices. Also, they contend that ANWR development would cause irreparable harm to the fragile tundra of the coastal plain and its wildlife. Broader impacts could include oil spills, waste disposal, and air pollution and carbon dioxide emissions. Further, they contend that energy efficiency measures, especially improved fuel efficiency for cars and light trucks, would save far more oil than ANWR can produce. Thus, they say, energy efficiency could do more to lower oil imports and prices while reducing, instead of increasing, environmental impacts.

This report describes the range of estimates for potential oil production from the Arctic National Wildlife Refuge (ANWR). The high and low estimates for an economically recoverable oil resource or "reserve" are then expressed in terms of an average or "levelized" daily production over assumed 20- and 50-year reserve lifetimes. Also, the report looks at measures for reducing oil use or displacing it with alternative fuels to see if any one measure or combination of measures would constitute an option for yielding an equivalent to the amount of oil that is projected to be available if ANWR were brought into production. To facilitate comparison with

ANWR production, the total fuel potential for each measure was estimated over a 20- and a 50-year cumulation period and then expressed as a levelized daily value. Although several illustrations of measures and options may be possible, this report is limited to a discussion of only two measures, fuel economy and cellulosic ethanol.

The report concludes with a summary and comparison of ANWR projections with those for fuel economy and cellulosic ethanol. It finds that fuel economy improvement through the first 20 years would generate average daily oil savings equivalent to about four times the low case and three-fourths of the high case projected for ANWR oil production. Extended through 50 years, the fuel economy savings would range from 10 times the low case to double the high case for ANWR. Also, cellulosic ethanol production through the first 20 years would generate average daily oil savings equivalent to one-fifth of the low case and about 4% of the high case projected for ANWR. Extended through 50 years, the savings from increased ethanol use would be equivalent to about three-fourths of the low case and about 16% of the high case for ANWR.

Potential Oil Production from ANWR

Assuming an oil price of $25.16 per barrel,[1] the U.S. Geological Survey estimates that there is a 95% chance that the economically recoverable oil resources in ANWR are 2.03 billion barrels or more of crude oil and a 5% chance that the resources are greater than 9.37 billion barrels.[2] USGS draws a careful distinction between definitions of oil "resources" and oil "reserves." For consistency with practice by industry and EIA, this memo uses the term "estimated economically recoverable oil reserves" to refer to what USGS defines as resources.[3]

Time Lag to First Oil Production. The Energy Information Administration (EIA) estimates that from approval to develop oil from the ANWR area, it would take seven to 12 years until the first production of oil begins.[4] Further, EIA notes that this time lag could vary significantly, depending on the time required for leasing, environmental and regulatory requirements, and the possibility of operational delays.

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[1]The U.S.G.S. uses a 1996 value of $24.00. Using the Gross Domestic Product Chained Price Index to adjust for inflation through 1999 yields a value of $25.16. Since late 1998, the average world market price of crude oil has ranged from below $10 to about $35 per barrel.

[2]U.S. Geological Survey (USGS). *The Oil and Gas Resource Potential of the Arctic National Wildlife Refuge 1002 Area, Alaska.* 1999. USGS Open File Report 98-34. Summary and Table EA4.

[3]USGS defines "undiscovered resources" as "resources postulated from geologic information and theory to exist outside of known oil and gas fields." Further, USGS defines measured or proved "reserves" as the identified economic resource that is estimated from geologic evidence supported directly by engineering data (including that from exploratory and producing wells). Measured reserves are demonstrated with reasonable certainty to be recoverable in future years from known reservoirs under existing economic and operating conditions.

[4]U.S. Dept. of Energy. Energy Information Administration (EIA). *Potential Oil Production from the Coastal Plain of the Arctic National Wildlife Refuge: Updated Assessment (ANWR Oil Production Assessment).* Chapter 2, Analysis Discussion. May 2000. [SR/O&G/2000-02] p. 4.

Development Rate and Time Lag to Peak Production. Once production began there would be another time lag until peak production is reached. Depending on the amount of oil present, this period is determined by the development rate, which, in turn, is determined primarily by the number of wells drilled per year.[5] However, oil prices and technology advancements can also influence the development rate. For each reserve estimate, EIA assumes a low and high development rate to show the effect of accelerated development.[6] Given the range in estimated reserves, the resultant estimates of time to peak production range from 22 to 25 years.

Pipeline Capacity Constraint. There is some available pipeline capacity to support oil production from ANWR. However, USGS and EIA note that higher rates of production from ANWR could be limited by the lack of available pipeline capacity. The Trans-Alaskan Pipeline currently supports about 1 million b/d from all existing North Slope oil fields and could accommodate another 1.2 to 1.4 million b/d from other future sources including ANWR.[7]

Levelized Oil Production Rates. The production cycle is likely to follow a growth curve with a peak and a declining tail. However, to simplify comparison with energy efficiency and conservation measures, a "levelized" daily value is calculated by averaging production over the entire productive life of the reserve. For a 50-year case, this is obtained by assuming that the estimated reserve is produced and dividing the reserve estimate by the number of days in the period. For a 20-year case, the oil production projected for first 20 years is divided by the number of days in the period. Attached Figures 1, 2, 3, and 4 show the projected production from ANWR under different assumptions for reserve size, development rate, and production period. Table 1 shows the resultant estimates of levelized daily production rates from ANWR.

Under these assumptions, including a crude oil price of $25.16 per barrel, Table 1 shows that the rate of oil production from ANWR could vary from a low of about 111,000 b/d averaged over 50 years to a high of about 845,000 b/d averaged over 20 years.

Potential Oil Savings from Selected Energy Efficiency and Renewable Energy Measures

Light Duty Fleet Fuel Economy Increase. An increase in the fuel economy of the nation's fleet of light-duty vehicles is one measure that could provide

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[5]EIA, *ANWR Oil Production Assessment*, p. 3. EIA's oil production model assumes development rates that reach peak production in the third year at about 10 percent of the annual development volume. The development rate also determines the resultant peak daily production rate.

[6]EIA notes that development rates in the early years may exceed those of later years, but uses constant development rates for its analyses.

[7]Personal communication with Mr. Floyd Wiesappe, EIA. April 16, 2001. Personal communication with Ms. Frances Pierce, USGS, April 12, 2001.

savings in gasoline use to curb oil demand.[8] The light-duty fleet comprises passenger cars and light trucks (which includes pickup trucks, minivans, and sport utility vehicles). The Energy Information Administration (EIA) provides an illustration of

Table 1. ANWR Daily Oil Production Estimate
(Varies with Reserve Size, Development Rate, and Lifetime)
(Assumes $25.16 per barrel world crude oil price)

Assumed Reserve & Development Rate	Average Daily Production, levelized over the period (barrels per day, b/d)*	
Reserve = 2.03 billion barrels	20-years (2010-2030)	50-years (2010-2060)
(a) Development Rate = 100 million barrels per year	167,000 b/d	111,000 b/d
(b) Development Rate = 200 million barrels per year	224,000 b/d	111,000 b/d
Reserve = 9.37 billion barrels		
(a) Development Rate = 350 million barrels per year	601,000 b/d	513,000 b/d
(b) Development Rate = 500 million barrels per year	845,000 b/d	513,000 b/d

Source: EIA. ANWR Oil Production Assessment. Production model for Figure 3, adapted to economically recoverable reserve cases for 2.03 and 9.37 BBbls.

* The barrels per day were calculated by adapting an EIA production model (5.7 BBbls) from the *ANWR Oil Production Assessment* to the two cases (2.03, 9.37) of "economically" recoverable reserves shown above. Each 50-year case assumes that the entire potential of the reserve is produced during the period. Each 20-year case takes the first 20 years of oil production projected by the model and divides by the number of days in the corresponding period to find the average.

the potential gasoline savings from energy efficiency improvements. For the period from 1999 through 2020, EIA's *International Energy Outlook 2001* projects fuel

[8]Each barrel of oil contains 42 gallons. In physical terms, less than half (19.2 gallons) of each barrel of crude oil is converted to motor gasoline, and the remainder is converted to other petroleum products. However, in conformance with other DOE and EIA volumetric data, each barrel of gasoline is assumed to be equivalent to a barrel of oil. See: U.S. EIA. Energy Information Sheets. July 1992. p. 2.

economy and gasoline use for a "reference" case and a "high technology" case.[9] For all cases, EIA assumes no increase in corporate average fuel economy (CAFE) standards. The reference case assumes that the only impact on fuel economy comes from the existing CAFE standard and a fuel economy tire labeling program.[10] This case also assumes that the number of light duty vehicles increases from 191 million in 1999 to 223 million in 2010 and 243 million in 2020.[11]

For the high technology case, EIA projects a greater net fuel economy increase due to the use of new technologies that include a direct-injection diesel vehicle; electric and electric hybrid vehicles with higher efficiencies, lower costs, and earlier introduction dates than in the reference case; and fuel cell gasoline, methanol, and hydrogen vehicles.[12] This case assumes that the number of light duty vehicles increases from 191 million in 1999 to 224 million in 2010 and 246 million in 2020.[13] Further, the high technology case is a technical scenario; it does not make explicit assumptions about what federal policies beyond those in the reference case would be needed to facilitate the higher level of technical improvements.[14] Table 2 shows EIA's projected gasoline savings through 2020 for the high technology case over the reference case, and assumes the same annual "frozen" savings rate continues through 2050,[15] and reports the cumulative gasoline savings that would constitute a fuel economy "reserve."

To make the gasoline savings projections for the fuel economy "reserve" more directly comparable to the estimated production from ANWR, the accumulated savings were converted into levelized average daily savings. Figure 5 shows the trend in EIA's projected gasoline savings and the estimates of levelized savings for

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[9]U.S. Dept. of Energy. Energy Information Administration (EIA). *Annual Energy Outlook 2001*. Table F4, Key Results for Transportation Technology Cases. December 2000. p. 219.

[10]EIA, *Annual Energy Outlook 2001*, p. 239-240.

[11]EIA. Personal communication with Mr. John Maples. April 11, 2001. EIA projects that the number of light trucks will grow rapidly, exceeding the number of cars . The number of cars stood at 121 million in 1999, but is projected to drop to 114 million in 2010 and 112 million in 2020. In contrast, there were 70 million light trucks in 1999; there are projected to be 109 million in 2010 and 131 million in 2020.

[12]EIA, *Annual Energy Outlook 2001*, p. 240.

[13]EIA. Personal communication with Mr. John Maples. April 11, 2001. See footnote 12 regarding EIA's projected growth in number of cars and light trucks.

[14]EIA. Personal communication with Mr. John Maples. April 11, 2001.

[15]The "frozen savings" case through 2050 was developed to create a 50-year savings period that could be directly compared with the 50-year period assumed to approximate the lifetime of oil production from ANWR. It assumes that a 3.6 mpg difference between a high technology case and a reference case stays constant from 2020 through 2050, saving 1,550 thousand barrels of gasoline per day through this period. This case is likely very conservative in that it assumes no further widening of the gasoline savings gap between the EIA reference case and the EIA high technology case.

Table 2. Light Duty Vehicle Fuel Economy: EIA Projected Gasoline Savings from "High Technology" Case for 2010 and 2020, with "Frozen Savings" Case for 2050[16] (Assumes constant dollar oil price of $17.84 in 1999 rising to $23.05 in 2020)*	
Average Fuel Economy, 1999	
Passenger Cars	21.4 miles-per-gallon (mpg)
Light Trucks	17.1 mpg
Combined Light Duty Fleet	20.5 mpg
Light-Duty Fleet Fuel Economy Improvement	
EIA 2010	1.4 mpg
EIA 2020	3.6 mpg
2050 (frozen at 2020 level)	3.6 mpg
Light-Duty Gasoline Savings Rate	
2010	0.55 million barrels per day (mb/d)
2020	1.56 mb/d
2050 (frozen at 2020 level)	1.56 mb/d
Fuel Economy "Reserve" (cumulative gasoline savings)	
1999 through 2010	1.11 billion barrels of oil equivalent
1999 through 2020	4.96 billion barrels of oil equivalent
1999 through 2050	21.99 billion barrels of oil equivalent

* Calendar year 1999 is the reference year. EIA. *Annual Energy Outlook 1999.* December 1998. EIA uses 1997 constant dollar oil prices of $17.35 and $22.41. The Gross Domestic Product (GDP) deflators published in Table 10.1 of the Historical Tables in the President's FY2002 Budget were used to convert these prices to 1999 constant dollar values of $17.84 and $23.05.

a 20-year and 50-year period.[17] Table 3 shows the resultant levelized values for gasoline savings. The levelized savings for the 20-year and 50-year projections are compared with ANWR levelized production values. Note that the EIA fuel economy projection assumes a world oil price ranging from $17.84 per barrel in 1999 to $23.05 per barrel in 2020, which is significantly lower than the $25.16 per barrel assumed in the projections for oil production from ANWR.[18]

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[16]EIA, *Annual Energy Outlook 2001*, Reference Case Forecast, p. 127. Oil prices are expressed in constant 1999 dollars.

[17]The time differences are exactly 21 years and 51 years, but they have been shortened to 20 years and 50 years to simplify the effort to compare with the 20-year and 50-year assumed lifetimes for ANWR. The 20-year and 50-year periods for ANWR are also a simplification from EIA models that project production over about 65 years, and make no explicit projection of a "blow-down" point where production is halted.

[18]ANWR oil production and fuel economy savings are both driven by oil price. However, in the studies reviewed, a higher oil price was assumed for ANWR than for fuel economy. Thus,

(continued...)

Table 3. Levelized (Average) Daily Gasoline Savings Estimate Varies with Cumulative Period of Savings from Fuel Economy Improvement (Assumes oil price of $17.84 in 1999 rising to $23.05 in 2020)	
Savings Period and Cumulative "Reserve"	Average Daily Savings, levelized over the period (barrels per day, b/d)*
10-year savings period (1999-2010): "Reserve" = 1.11 billion barrels equivalent	277,000 b/d
20-year savings period (1999-2020): "Reserve" = 4.96 billion barrels equivalent	647,000 b/d
50-year savings period (1999-2050): "Reserve" = 21.99 billion barrels equivalent	1,181,000 b/d
* The barrels per day were calculated by dividing the assumed amount of "reserves" by the number of days in the corresponding period.	

EIA projections of savings from the high technology case appear to assume that this case begins to be implemented in 2001.[19] So, after a period of about 10 years, roughly equivalent to the projected time lag for ANWR to reach first production, EIA projects that a "high technology" case would improve the national light duty fleet fuel economy by 1.4 mpg, with a resultant levelized daily oil savings of about 277,000 barrels per day.[20] This is larger than levelized daily production from ANWR under both the 20-year and 50-year scenarios that assume 2.03 billion barrels of reserves.

For the 20-year period, the EIA projection under the high technology case would improve fuel economy by about 3.6 mpg, with a levelized daily oil savings of about 647,000 barrels per day. Table 4 shows that this gasoline savings is larger than the levelized daily production from ANWR under all 20-year cases except for the 845,000 b/d average projected for the high development case under an assumed reserve of 9.37 BBbls.

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[18](...continued)
in places where the ANWR production estimate exceeds the fuel economy estimate, the gap is likely larger than would actually occur. Further, in places where the fuel economy estimate exceeds the ANWR estimate, the gap is likely smaller than would actually occur

[19]EIA. *Annual Energy Outlook 2001*. December 2000. Pp. 240.

[20]Given technology developments and the 80 mpg fuel economy goal of the Partnership for a New Generation of Vehicles (PNGV), some analysts find EIA's 2010 fuel economy projections to be overly conservative. DOE provides an example of a higher projection in its November 2000 report *Scenarios for a Clean Energy Future*. In Table 6.10 of the report, DOE projects that increased research and development spending and other factors under an "advanced scenario" could raise light duty fuel economy to 22.8 mpg by 2010, which is 0.5 mpg or 36% more than the EIA high technology case.

Table 4. ANWR Production Compared with Fuel Economy Gasoline Savings				
Part A. 20-year period (in barrels per day, b/d)				
ANWR Case (reserve, development rate)		Fuel Economy (1.4, 3.6)	Fuel Economy minus ANWR	Difference as % of ANWR
ANWR (2.03 BBbls, 100 MMBbls/yr)	167,000 b/d	647,000 b/d	480,000 b/d	287%
ANWR (2.03 Bbbls, 200 MMBbls/yr)	224,000 b/d	647,000 b/d	423,000 b/d	188%
ANWR (9.37 Bbbls, 350 MMBbls/yr)	601,000 b/d	647,000 b/d	46,000 b/d	8%
ANWR (9.37 Bbbls, 500 MMBbls/yr)	845,000 b/d	647,000 b/d	-198,000 b/d	-23%
Part B. 50-year period (in barrels per day, b/d)				
ANWR (2.03 BBbls)	111,000 b/d	1,181,000 b/d	1,070,000 b/d	963%
ANWR (9.37 BBbls)	513,000 b/d	1,181,000 b/d	668,000 b/d	130%

The 50-year projection assumes a 30-year freeze of the fuel economy improvement at 3.6 mpg, which results in a levelized daily gasoline savings of about 1,181,000 barrels per day. Table 4 shows that this savings is larger than the levelized daily oil production from ANWR under both 50-year cases. It is more than double the high production value of 513,000 b/d from ANWR.

Cellulosic Ethanol. About 1.3 billion gallons of ethanol produced from corn are currently used as a blend stock for gasoline. A recent DOE report, *Scenarios for a Clean Energy Future*, says that technology for producing cellulosic ethanol is one of the "most promising" alternatives to gasoline.[21] DOE estimates that up to 40 billion gallons of ethanol could be produced annually from cellulose in the form of woody biomass obtained from municipal wastes, agricultural wastes, and energy crops.[22]

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[21]U.S. DOE. *Scenarios for a Clean Energy Future.* Chapter 6, Transportation Sector. November 2000. p. 6.6.

[22]U.S. DOE. *Scenarios for a Clean Energy Future.* Chapter 6, Transportation Sector. (continued...)

DOE uses EIA models to estimate the potential for cellulosic ethanol to displace gasoline. The reference case in EIA's Annual Energy Outlook 1999 (AEO99) was adopted as the baseline scenario and assumes no changes in federal policy.[23] DOE creates an "advanced" scenario for the transportation sector, which assumes the development of a program to promote investment in cellulosic ethanol production.[24] Two key assumptions in the advanced scenario for cellulosic ethanol are identical to the baseline assumptions taken from EIA's AEO99 reference case. One, DOE's study used EIA's 1999 projection that the world oil price would sink to $14.37 per barrel in 2000 and then rise $23.38 per barrel in 2020.[25] Also, DOE assumes that the nominal value of the gasohol tax exemption does not expire in 2007, but continues at an inflation-reduced level.[26]

DOE's advanced scenario for ethanol does assume some federal policy changes. First, it assumes that industry and federal R&D spending is doubled.[27] Second, it assumes that cellulosic ethanol production cost is reduced by 50% compared to the current cost of producing ethanol from corn.[28] Third, it assumes that a program of loan guarantees or subsidies is put in place to eliminate some market risks for new ethanol plants.[29] Fourth, it assumes that there is no ban of methyl tertiary butyl ether (MTBE). DOE says a ban on MTBE could increase demand for ethanol as a blending stock.[30]

Figure 6 shows the trend in DOE's projected ethanol production and the estimates of levelized gasoline savings for a 20-year and 50-year period. Table 5

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[22](...continued)
November 2000. p. 6.6.

[23] DOE, *Scenarios*, p.6.1.

[24]DOE, *Scenarios*, p. 6-38. DOE also creates a "moderate" scenario. It assumes an identical program of support for ethanol. The projected amounts of ethanol production under the moderate and advanced scenarios are nearly identical. For 2010, the moderate case projects slightly higher production than the advanced case. For 2020, the advanced case projects a slightly higher amount of production.

[25]DOE, *Scenarios*, p. 6.6. Using 1997 constant dollar values, EIA's AEO99 reference case projects an oil price of $13.97 in 2000, rising to $22.73 in 2020. FY2002 GDP Price Index deflators were used to convert these projections to 1999 constant dollars. Also, DOE stresses that the market penetration of cellulosic ethanol will be critically dependent on the world market price of crude oil.

[26]DOE, *Scenarios*, p. 6.18 and 6.25.

[27]DOE, *Scenarios*, p. 6.16. This applies across-the-board to all transportation technologies in the report.

[28]DOE, *Scenarios*, p. 6.25 and 6.38. DOE states that this 50% cost reduction is consistent with goals of its R&D program and with optimistic estimates in the National Research Council's 1999 report *Review of the Reserach Strategy for Biomass-Derived Transportation Fuels*. Also, it notes that the AEO99 reference case assumes a 20% reduction relative to the current cost to produce ethanol.

[29]DOE, *Scenarios*, p. 6.25.

[30]DOE, *Scenarios*, p. 6.37.

Table 5. Light Duty Vehicle Ethanol Use: Gasoline Savings from DOE Projected Ethanol Use in 2010 and 2020, with "Frozen Savings" Case for 2050 (Assumes oil price of $14.37 per barrel in 2000 rising to $23.38 per barrel in 2020)[31]

Ethanol Blending in Place	
1999 Base Year	1.3 billion gallons of ethanol per year[32]
2010 Base Case	2.3 billion gallons per year[33]
2020 Base Case	3.3 billion gallons per year
Ethanol Production	
DOE 2010 Advanced Scenario	3.9 billion gallons per year
DOE 2020 Advanced Scenario	7.3 billion gallons per year
2050 (frozen at 2020 level)	7.3 billion gallons per year
Ethanol Blending: Net Increase[34] [35]	
DOE 2010	1.6 billion gallons per year
DOE 2020	4.0 billion gallons per year
2050 (frozen at 2020 level)	4.0 billion gallons per year
Light-Duty Gasoline Savings Rate	
2010	0.013 million barrels per day (mb/d)
2020	0.116 mb/d
2050 (frozen at 2020 rate)	0.116 mb/d
Cellulosic Ethanol "Reserve" (cumulative gasoline savings)	
1999 to 2010	0.03 billion barrels of oil equivalent
1999 to 2020	0.26 billion barrels of oil equivalent
1999 to 2050	1.53 billion barrels of oil equivalent

[31]EIA, *Annual Energy Outlook 1999*, Table A1: Reference Case Forecast. World oil price estimates.

[32]U.S. Dept. of Transportation. Federal Highway Administration. *Estimated Use of Gasohol 1999*. [Table MF-33E] October 2000.

[33]DOE, *Scenarios*, p. 6.38. The baseline estimates for ethanol in 2010 and 2020 are taken from Figure 6.13.

[34]CRS Report 98-435E. *Alcohol Fuels Tax Incentives: Current Law and Proposed Changes*, by (name redacted). The most important federal tax subsidy for ethanol fuels is a n exemption from the 18.4-cents per gallon excise tax on gasoline. Alcohol fuel blends with 10% or more ethanol and 90% or less gasoline qualify for the maximum 5.4-cents per gallon exemption. A smaller, prorated exemption is available for lower percentages of ethanol in the blend. Thus, the maximum incentive effect takes place where the alcohol share stands at 10%. Further, due to the corrosive effect of alcohol on certain parts of the automobile motor, there is a physical limit on the percentage of alcohol that can be put in the blend.

[35]DOE, *Scenarios for a Clean Energy Future*.

shows the projected gasoline savings through 2020, freezes the savings rate to 2050, and estimates the cumulative gasoline savings that could constitute a cellulosic ethanol "reserve."

To make the gasoline savings projections for the ethanol "reserve" more directly comparable to the estimated production from ANWR, the accumulated savings were converted into levelized average daily savings. Table 6 shows the resultant levelized values for gasoline savings. The levelized savings for the 20-year and 50-year projections are used to compare with ANWR levelized production values in Table 7. Note that the EIA fuel economy projection assumed a world oil price ranging from $14.37 per barrel in 1999 to $23.38 per barrel in 2020, which is significantly lower than the $25.16 per barrel price assumed in the projections for oil production from ANWR.[36]

Table 6. Levelized (Average) Daily Gasoline Savings from Ethanol Displacement: Estimate Varies with Cumulation Period
(Assumes oil price of $14.37 per barrel in 2000 rising to $23.38 per barrel in 2020)

Savings Period and Cumulative "Reserve"	Average Daily Savings, levelized over the period (barrels per day, b/d)*
11-year savings period (1999-2010): "Reserve" = 0.03 billion barrels equivalent	6,000 b/d
20-year savings period (1999-2020): "Reserve" = 0.26 billion barrels equivalent	34,000 b/d
50-year savings period (1999-2050): "Reserve" = 1.53 billion barrels equivalent	82,000 b/d

* The barrels per day were obtained by dividing the assumed amount of "reserves" by the number of days in the corresponding period.

So, by 2010, a period roughly equivalent to the projected time lag for ANWR to reach first production, DOE projects that ethanol production could reach a gasoline savings rate equivalent to 3,000 b/d with a levelized value over that period of 1,500 b/d.

For the 20-year period, the DOE projection to 2020 would increase the gasoline equivalent from ethanol production to a levelized daily savings of 34,000 b/d. Table

[36] ANWR oil production and cellulosic ethanol production are both driven by oil price. However, in the studies reviewed, a higher oil price was assumed for ANWR than for cellulosic ethanol. Thus, the gap between ANWR and ethanol estimates is likely larger than would actually occur.

7 shows that this gasoline savings is 80% to 96% smaller than the levelized daily production from ANWR under the 20-year cases.

Table 7. ANWR Production Compared with Gasoline Savings from Ethanol				
Part A. 20-year period (in barrels per day, b/d)				
ANWR Case (reserve, development rate)		Ethanol	Ethanol minus ANWR	Difference as % of ANWR
ANWR (2.03, 100)	167,000 b/d	34,000 b/d	-133,000 b/d	-80%
ANWR (2.03, 200)	224,000 b/d	34,000 b/d	-190,000 b/d	-85%
ANWR (9.37, 350)	601,000 b/d	34,000 b/d	-567,000 b/d	-94%
ANWR (9.37, 500)	845,000 b/d	34,000 b/d	-811,000 b/d	-96%
Part B. 50-year period (in barrels per day, b/d)				
ANWR (2.03)	111,000 b/d	82,000 b/d	29,000 b/d	-26%
ANWR (9.37)	513,000 b/d	82,000 b/d	-431,000 b/d	-84%

For the 50-year period, ethanol production is frozen at the 2020 level in the 30-year period through 2050, resulting in a levelized daily gasoline savings equivalent of about 82,000 b/d. Table 7 shows that this savings is about 26% less than the 111,000 b/d levelized daily oil production projected under the 50-year ANWR case with a 2.03 BBbls reserve. Also, it is 84% less than the 513,000 b/d levelized production under the 50-year ANWR case with a 9.37 BBbls reserve.

Summary and Comparison of Projections

With a world oil price of $25.16 (in 1999 dollars) per barrel, the U.S. Geological Survey estimates ANWR's economically recoverable resources range from 2.03 to 9.37 billion barrels of oil (BBbls). Assuming a 20-year production period, projected levelized (average) daily oil production could range from 167,000 barrels per day (b/d) to 845,000 b/d. For a 50-year period, levelized daily oil production could range from 111,000 barrels per day (b/d) to 513,000 b/d.

In comparison, under a world oil price ranging from $17.84 in 1999 rising to $23.05 in 2020, an Energy Information Administration (EIA) fuel economy projection to 2020 leads to a 20-year accumulated "reserve equivalent" of 4.96 billion barrels, with an average daily savings of 647,000 b/d. Continuing or "freezing" the savings rate to 2050 would yield a 50-year accumulated reserve equivalent of 21.99 billion barrels, with an average daily savings of 1,181,000 b/d.

Similarly, under a world oil price ranging from $14.37 per barrel in 2000 rising to $23.38 per barrel in 2020, a Department of Energy (DOE) ethanol fuel projection to 2020 leads to a 20-year accumulated "reserve equivalent" of 0.26 billion barrels (BBbls) of oil, with an average daily gasoline savings of 34,000 b/d. Freezing the savings rate to 2050 leads to a 50-year accumulated reserve equivalent of 1.53 billion barrels, with an average daily savings of 82,000 b/d.

Table 8 compares the ANWR projections with those for fuel economy and cellulosic ethanol. It shows that fuel economy savings exceeds ANWR production

Table 8. Projections of Levelized Daily Production from ANWR Reserves Compared with Gasoline Savings from Improved Fuel Economy and Increased Ethanol Use
(for 20- and 50-year periods, in barrels per day, b/d)

Source	World Oil Price ($1999 constant)	20-year	50-year
ANWR, Economically Recoverable Reserves	$25.16 per barrel	167,000 b/d to 845,000 b/d	111,000 b/d to 513,000 b/d
Fuel Economy, Equivalent "Reserve"	$17.84 rising to $23.05 per barrel	647,000 b/d	1,181,000 b/d
Cellulosic Ethanol, Equivalent "Reserve"	$14.37 rising to $23.38 per barrel	34,000 b/d	82,000 b/d

in all cases except for the 20-year case for high ANWR production, where fuel economy supplies three-fourths of the ANWR projection. In contrast, oil displacement from cellulosic ethanol is far below ANWR production in all cases except for the 50-year case for low ANWR production, where ethanol reaches nearly three-fourths of the ANWR projection. Another pattern is present. The savings from fuel economy relative to ANWR production grows with the length of the projection period. The same is true for ethanol. Also, the lower oil prices assumed for fuel economy and ethanol tend to dampen the projection of their savings potential relative to ANWR production.

For Additional Reading:

CRS Issue Brief IB10073. *The Arctic National Wildlife Refuge: The Next Chapter*, by (name redacted) and Bernard Gelb.

CRS Report RL31022. *Arctic Petroleum Development: Implications of Advances in Technology*, by Terry R. Twyman.

CRS Issue Brief IB90122. *Automobile and Light Truck Fuel Economy: Is CAFÉ Up To Standards?*, by Rob Bamberger.

CRS Report RL30369. *Fuel Ethanol: Background and Public Policy Issues*, by (name redacted).

Table 9. Fuel Economy Equivalent to ANWR, for Light Duty Fleet

Source: EIA. Annual Energy Outlook 2001. Table F4: Transportation Technology Cases

	1999	2010	2020	2030	2040	2050	
Fuel Economy, mpg							
Reference	20.5	20.9	21.5			21.5	1999 Base = 20.5 miles per gallon
High Technology	20.5	22.3	25.1			25.1	
Difference	0	1.4	3.6			3.6	1 barrel of gasoline = 5.25 million Btu
							1 year = 365 days
Annual Gasoline Use, Q/yr							
Reference	15.25	18.22	20.63			20.63	LIght duty vehicles accounted for 15.25 Q/yr of motor gasoline use in 1999.
High Technology	15.25	17.16	17.65			17.65	For the reference case, EIA projects 18.22 Q/yr in 2010 and 20.63 Q/yr in 2020.
Difference	0.00	1.06	2.98			2.98	For the high technology case, EIA projects 17.16 Q/yr in 2010 and 17.65 Q/yr in 2020.
							Source: EIA. Personal communication with Mr. John Maples. April 11, 2001.
Daily Gasoline Use, mb/d							
Reference	7.96	9.51	10.77			10.77	1 Q/yr = 0.52185258 million barrels of gasoline per day
High Technology	7.96	8.95	9.21			9.21	
Difference	0.00	0.55	1.56			1.56	1 Q = 190.47619 million barrels of gasoline per
thousand barrels of oil/day	0	553	1555			1555	
Cumulative Gasoline Savings							
Q gasoline	0	5.83	26.03			115.43	2010 Cumulative = 0.5 X (1.06-0) X (2010-1999) = 5.83 Q
billion barrels gasoline	0	1.11	4.96			21.99	2020 Cumulative = 5.83 + 0.5 X (2.98-1.06) X (2020-2010) + 1.06 X (2020-2010) = 26.03 Q
							2050 Cumulative = 26.03 + 2.98 X (2050-2020) = 115.43 Q
Fuel Economy Reserve							
billion barrels oil equivalent	**0**	**1.11**	**4.96**			**21.99**	
							Estimate of levelized savings = cumulative gasoline savings/ # days in period
Levelized Average Savings							2010 levelized savings = (1.11 X 1000) / (2010-1999)*365 = 0.277 million barrels per day
billion barrels crude oil/year		0.101	0.236			0.431	2020 levelized savings = (4.96 X 1000) / (2020-1999)*365 = 0.647 million barrels per day
million barrels of oil/day		**0.277**	**0.647**			**1.181**	2050 levelized savings = (21.99 X 1000) / (2050-1999)*365 = 1.181 million barrels per day
thousand barrels of oil/day		277	647			1181	

Table 10. Cellulosic Ethanol Equivalent to ANWR, for light duty fleet

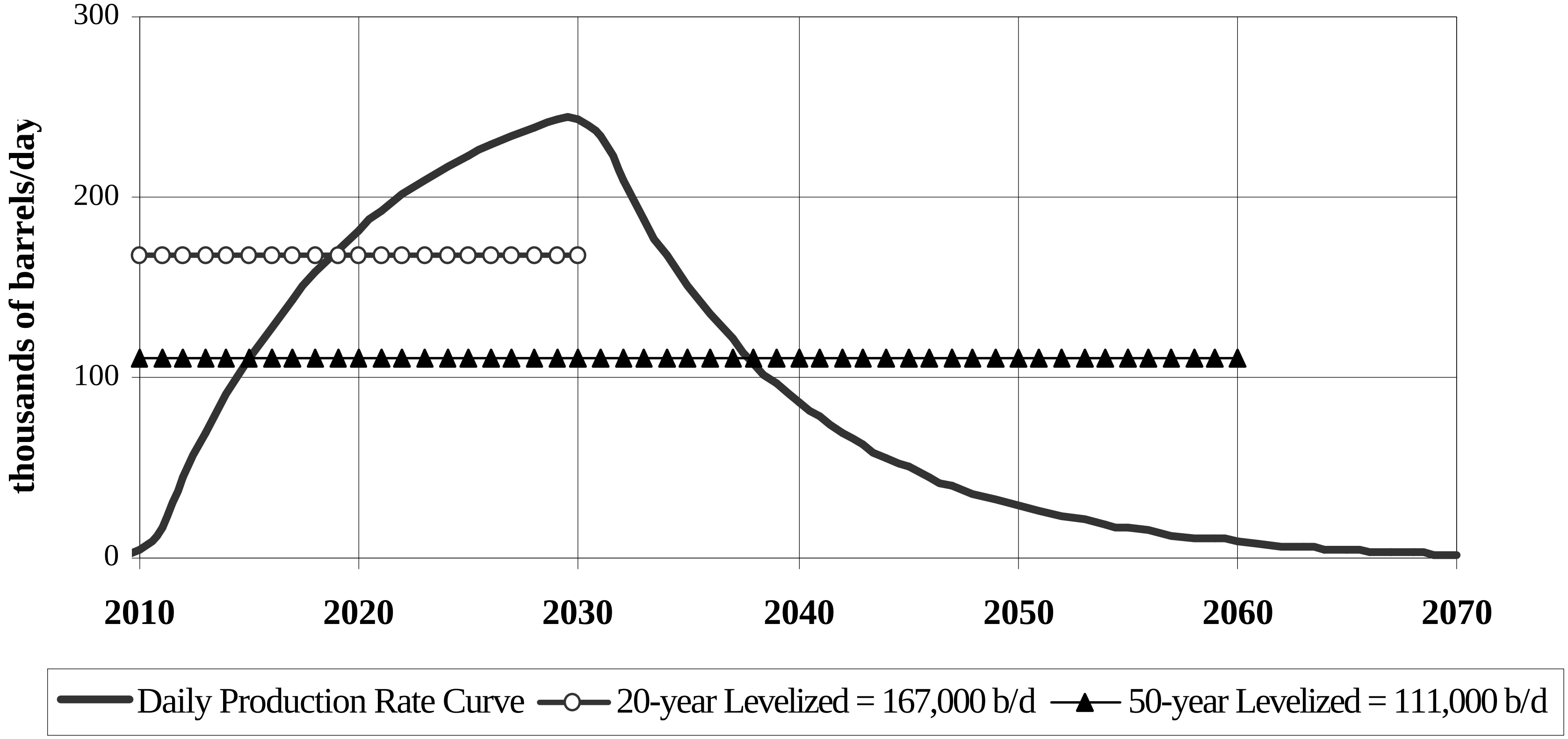
Source: DOE. Scenarios for a Clean Energy Future. Chapter 6: Transportation Sector.

	1999	2010	2020	2030	2040	2050	
Ethanol Blending, billion gals/year							
Total	1.30	1.60	4.00			4.00	1999 Base = 1.3 billion gallons per year
Net Increase Over 1999 Base	0.00	0.30	2.70			2.70	
Gasoline Savings Equivalent							
billion gallons/year	0.00	0.20	1.78			1.78	Ethanol Btu content = 0.66 Gasoline Btu content
million barrels/year	0.00	4.71	42.43			42.43	
million barrels/day	0.00	0.013	0.116			0.116	
Cumulative Gasoline Savings							2010 Cumulative = 0.5 X (4.71-0) X (2010-1999) = 25.93 million barrels
million barrels gasoline	0	25.93	261.64			1534.50	2020 C've. = 25.93 + ((0.5 X (42.43-4.71)) + 4.71) X (2020-2010) = 261.64 million barre
billion barrels gasoline	0	0.026	0.262			1.535	2050 Cumulative = 261.64 + 42.43 X (2050-2020) = 1535 million barrels
Cellulosic Ethanol Reserve							
billion barrels oil equivalent	**0**	**0.03**	**0.26**			**1.53**	
Levelized Average Savings							2010 levelized savings = (0.03 X 1000) / (2010-1999)*365 = 0.006 million barrels per da
billion barrels crude oil/year		0.002	0.012			0.030	2020 levelized savings = (0.26 X 1000) / (2020-1999)*365 = 0.034 million barrels per da
million barrels of oil/day		**0.006**	**0.034**			**0.082**	2050 levelized savings = (1.53 X 1000) / (2050-1999)*365 = 0.082 million barrels per da

Figure 1. ANWR Daily Oil Production (2.03, 100)

(Reserve = 2.03 billion barrels; Develop. Rate = 100 MMBbls/year)

Source: EIA, ANWR Oil Production Assessment, May 2000. Adapted from Fig.3 to 2.03 BBbls of "economically" recoverable oil.



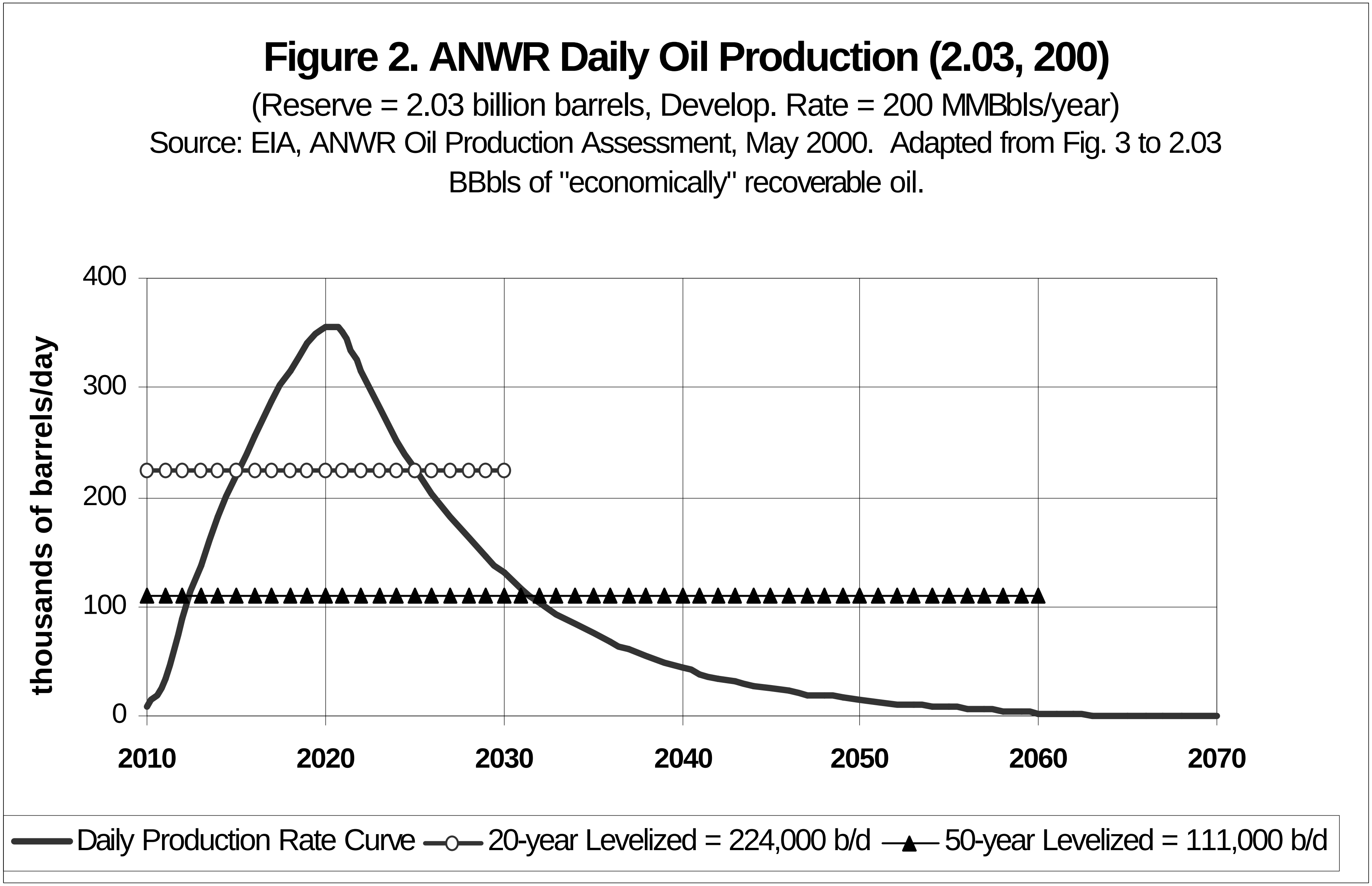


Figure 2. ANWR Daily Oil Production (2.03, 200)
(Reserve = 2.03 billion barrels, Develop. Rate = 200 MMBbls/year)
Source: EIA, ANWR Oil Production Assessment, May 2000. Adapted from Fig. 3 to 2.03 BBbls of "economically" recoverable oil.
thousands of barrels/day
400
300
200
100
0
2010
2020
2030
2040
2050
2060
2070
Daily Production Rate Curve
20-year Levelized = 224,000 b/d
50-year Levelized = 111,000 b/d

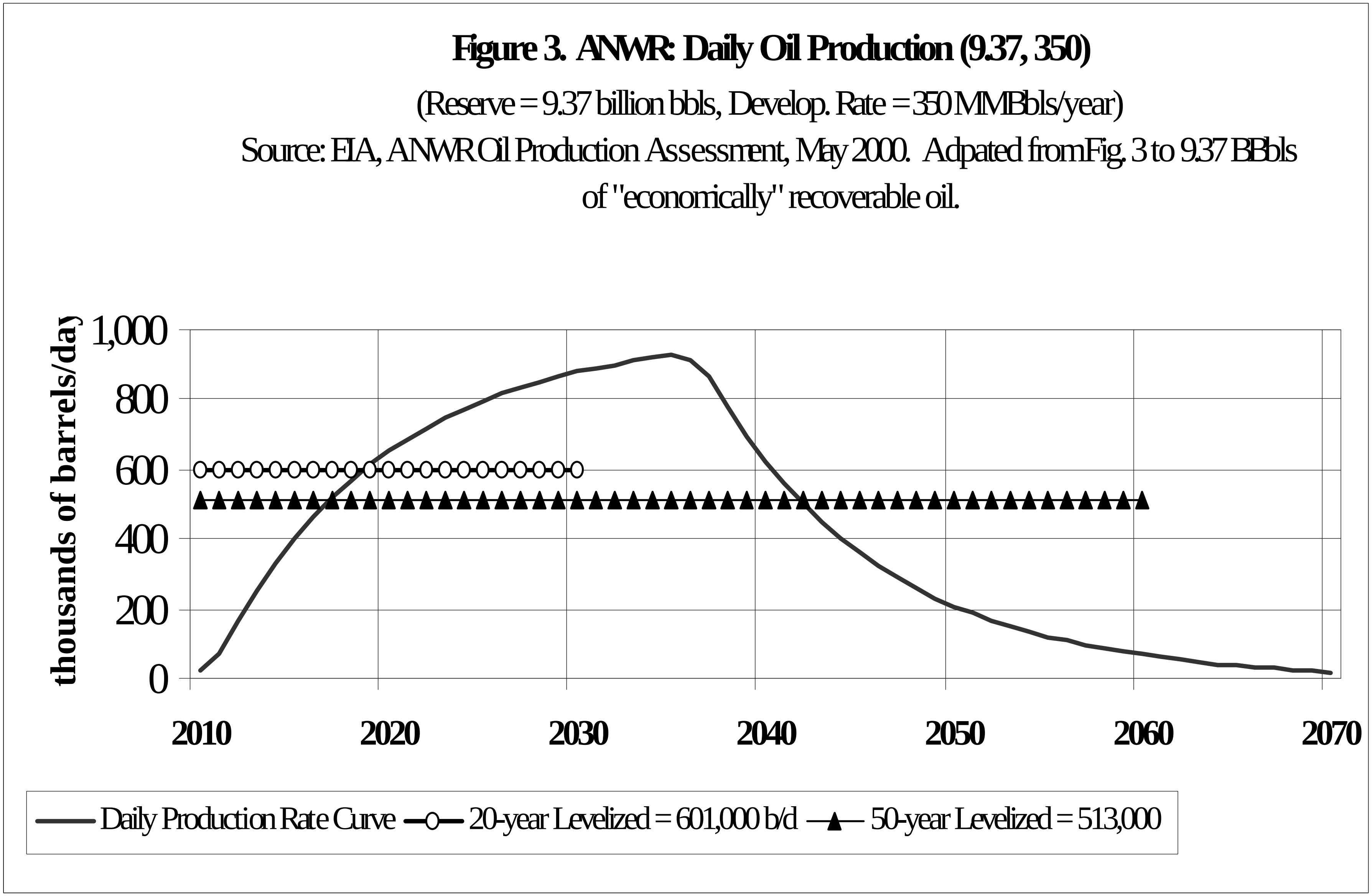


Figure 3. ANWR: Daily Oil Production (9.37, 350)
(Reserve = 9.37 billion bbls, Develop. Rate = 350 MMBbls/year)
Source: EIA, ANWR Oil Production Assessment, May 2000. Adpated from Fig. 3 to 9.37 BBbls
of "economically" recoverable oil.
thousands of barrels/day
1,000
800
600
400
200
0
2010
2020
2030
2040
2050
2060
2070
Daily Production Rate Curve
20-year Levelized = 601,000 b/d
50-year Levelized = 513,000

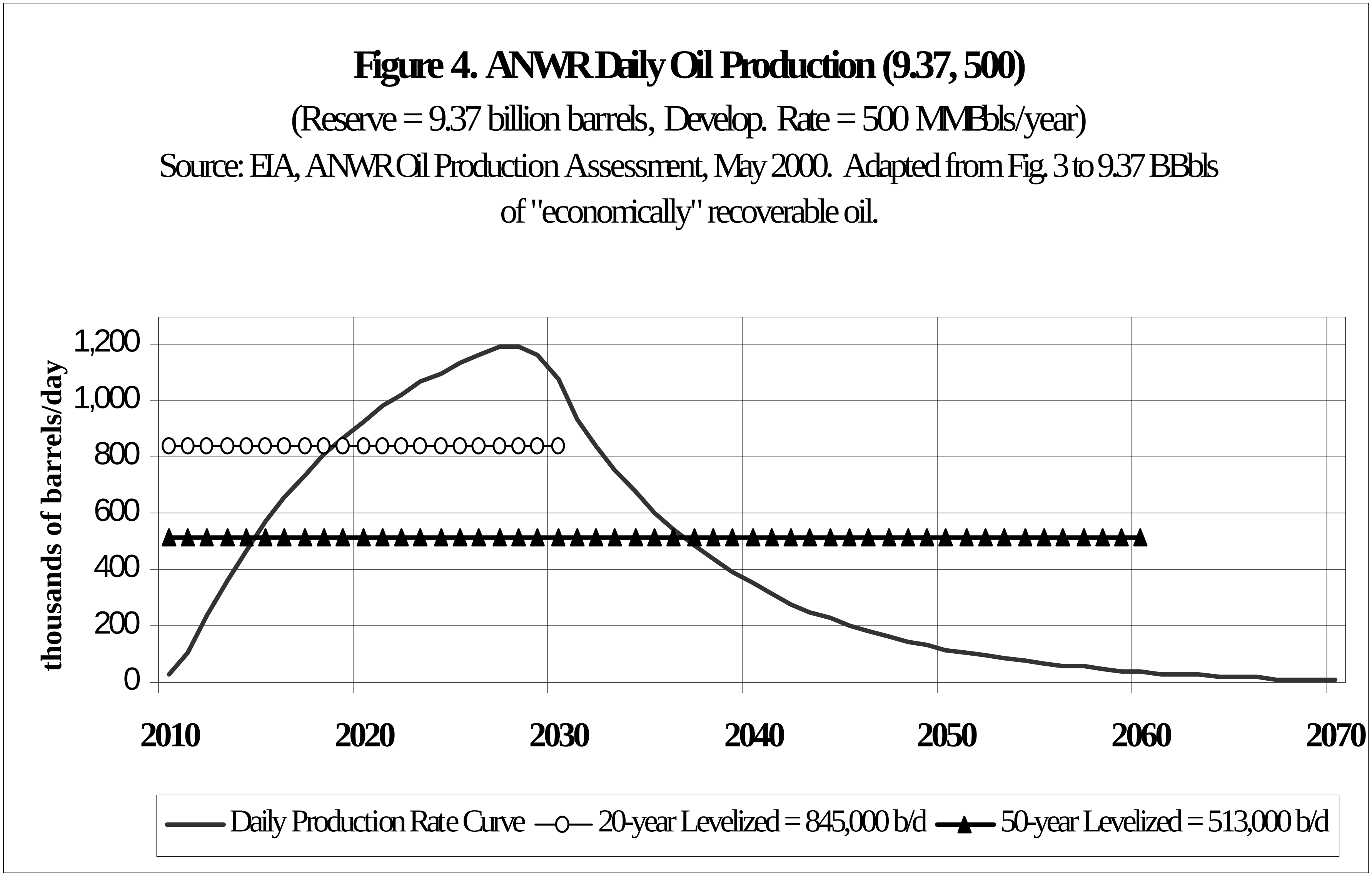


Figure 4. ANWR Daily Oil Production (9.37, 500)
(Reserve = 9.37 billion barrels, Develop. Rate = 500 MMBbls/year)
Source: EIA, ANWR Oil Production Assessment, May 2000. Adapted from Fig. 3 to 9.37 BBbls of "economically" recoverable oil.
thousands of barrels/day
1,200
1,000
800
600
400
200
0
2010
2020
2030
2040
2050
2060
2070
Daily Production Rate Curve
20-year Levelized = 845,000 b/d
50-year Levelized = 513,000 b/d

Figure 5. Fuel Economy, Daily Gasoline Savings

(20-year "reserve" = 4.96 BBbls, 50-year "reserve" = 21.99 BBbls)

Source: EIA, Annual Energy Outlook 2001, Table F4.

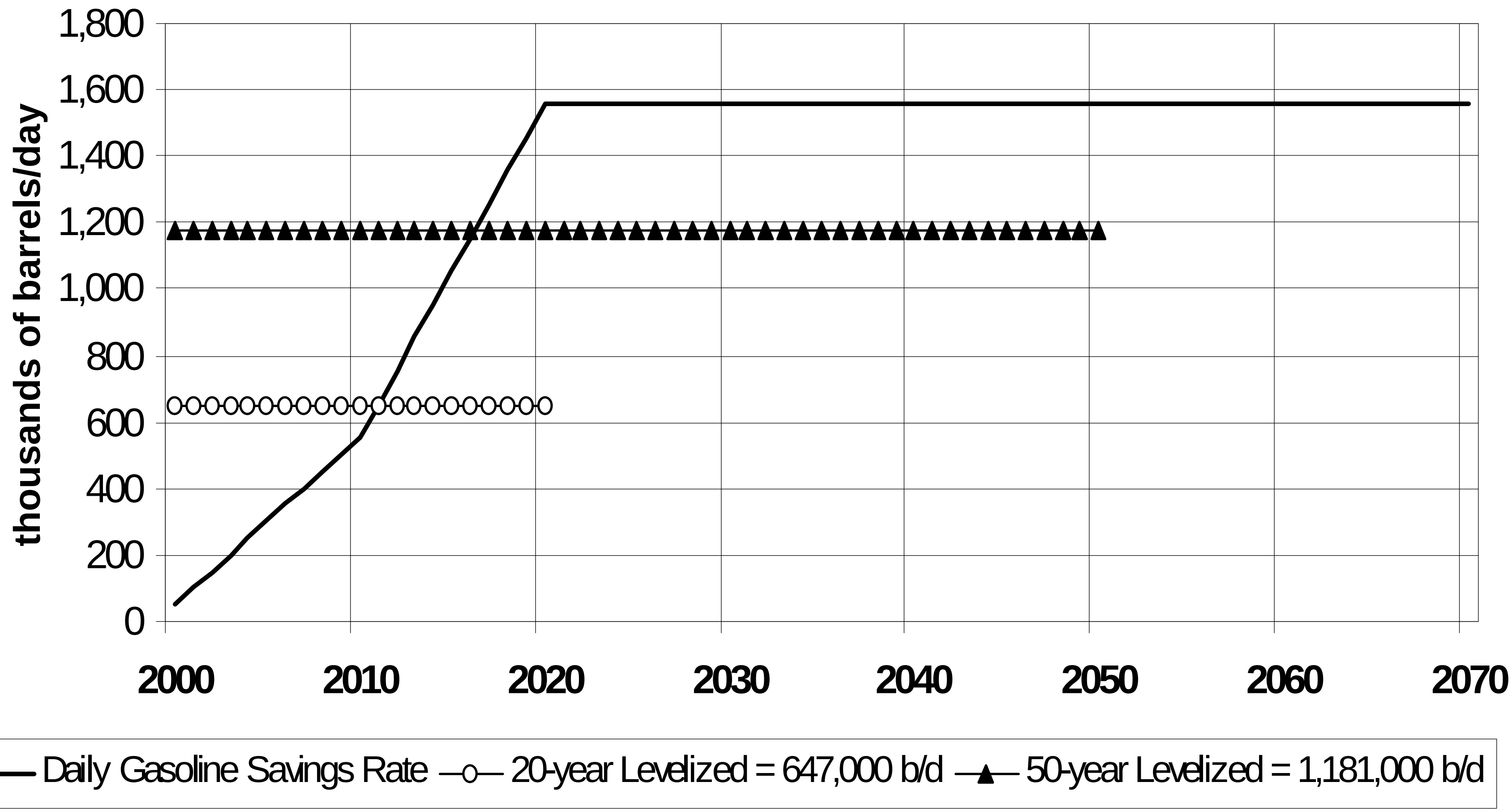


Figure 6. Cellulosic Ethanol, Daily Gasoline Savings

(20-year "reserve" = 0.26 BBbls, 50-year "reserve" = 1.53 BBbls)

Source: DOE, Scenarios for a Clean Energy Future, Chapter 6.