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U.S. Crude Oil Production Forecast-Analysis of Crude Types

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Preface

U.S. oil production has grown rapidly in recent years. U.S. Energy Information Administration (EIA) data, which reflect combined production of crude oil and lease condensate, show a rise from 5.7 million barrels per day (bbl/d) in 2011 to 7.4 million bbl/d in 2013. EIA's *Short-Term Energy Outlook (STEO)* projects continuing rapid production growth in 2014 and 2015, with forecast production in 2015 reaching 9.2 million bbl/d. Beyond 2015, EIA's *Annual Energy Outlook (AEO)* projects further production growth, although its pace and duration remain uncertain. Domestic production plateaus near 9.6 million bbl/d between 2017 and 2020, close to its historical high of 9.6 million bbl/d in 1970, in the AEO2014 Reference case. In the AEO2014 High Oil and Gas Resource case, growth continues through the 2020s and into the 2030s, with production reaching 13.3 million barrels per day in 2036.

Recent and forecast increases in domestic crude production have sparked discussion on the topic of how rising crude oil volumes will be absorbed. In early 2013, several commentators had suggested that near-term production growth would be threatened unless restrictions on U.S. exports of crude oil were significantly relaxed. EIA's perspective at the time was somewhat more nuanced, recognizing that relaxation of export restrictions was only one among several ways to absorb growing near-term flows of domestic production. (This Week In Petroleum, Absorbing increases in U.S. crude oil production, May 1, 2013)

Given the likelihood of continued growth in domestic crude production, and the recognition that some absorption options, such as like-for-like replacement of import streams, are inherently limited, the question of how a relaxation in current limitations on crude exports might affect domestic and international markets for both crude and products continues to hold great interest for policymakers, industry, and the public. In response to multiple requests, EIA is developing analyses that shed light on this question.

This paper provides a short-term forecast of domestic production by crude type, supplementing the overall production forecast provided in STEO. Forecasts of production by crude type matter for several reasons. First, U.S. crude streams vary widely in quality. Second, the economics surrounding various options for the domestic use of additional domestic oil production are directly dependent on crude quality characteristics. Third, actual or potential export values also vary significantly with quality characteristics.

The production forecast analysis of crude oil characteristics provided in this paper provides a starting point for further analyses of the market outlook and the effects of a possible relaxation of existing restrictions on crude oil exports.

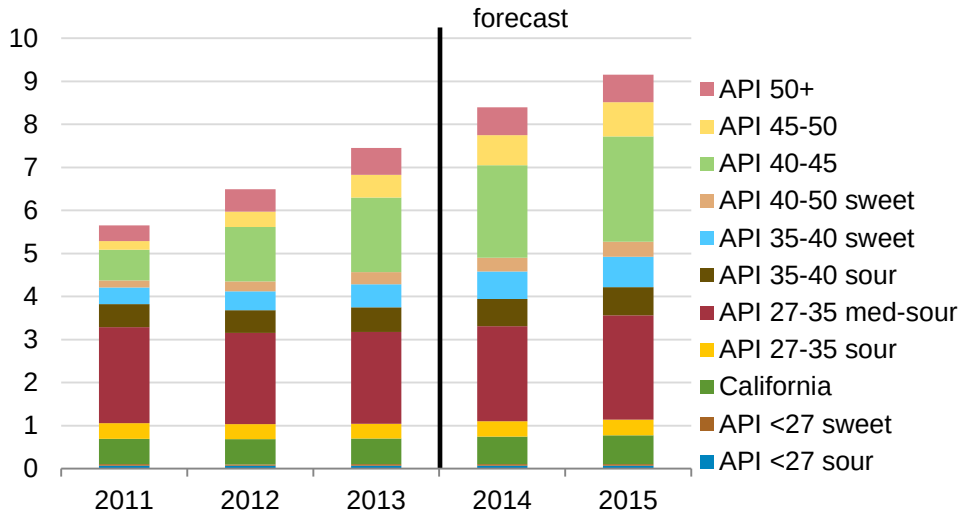
Summary Findings: Recent and Forecast U.S. Production by Crude Type

Recent U.S. crude oil production growth has consisted primarily of lighter, sweet crude (a description of crude quality, as measured by API gravity and sulfur content) from tight resource formations. Roughly 96% of the 1.8 million bbl/d growth in production between 2011 and 2013 consisted of sweet grades with API gravity of 40 or above.

EIA analysis of current and forecast crude oil production indicates that U.S. supply of lighter API gravity crude will continue to outpace that of medium and heavier crudes (Figure 1). More than 60% of EIA's forecast of production growth for 2014 and 2015 consists of sweet grades with API gravity of 40 or above.

Figure 1. U.S. crude oil production by crude type

million barrels per day



Source: EIA, DrillingInfo, Colorado DNR, Texas RRC.

The estimates presented in this paper reflect EIA's current assessment based on available data. The quality and timeliness of well-level data on production by crude type used to develop the estimates vary widely across states. As part of its continuing effort to improve data on oil and natural gas production, EIA is now seeking public comment on a plan to expand its current collection of monthly natural gas production data in 6 states to include both oil and natural gas production in 21 states. The proposed data collection, which EIA plans to launch in 2015, would provide information on production by crude type. Updated estimates of regional production by crude type will also be needed as new plays start commercial development, because production from new plays will change the distribution of production by crude types in the regions where those plays are located. (Federal Register Notice, http://www.eia.gov/pressroom/releases/press408.cfm)

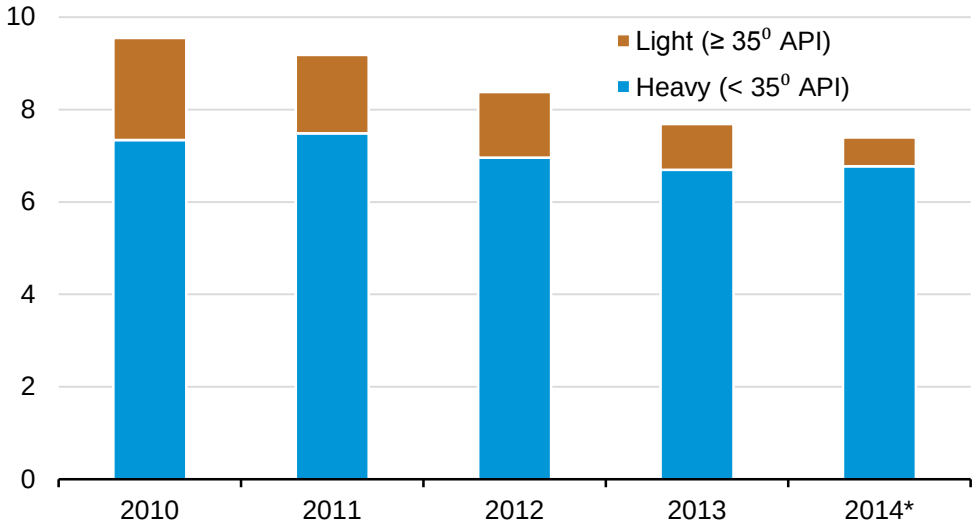
Although the topic of how future increases in domestic oil production might be absorbed into the market will be the topic of future analyses, data regarding recent experience along with brief qualitative insights regarding the future provide some important context.

Additional production of light oil over the past several years has for the most part been absorbed by reducing oil imports of similar grades. Of the total 1.5-million-bbl/d decline in crude oil imports between 2011 and 2013, nearly 50% was light crude (API gravity 35+). Light crude imports fell from 1.7 million bbl/d in 2011 to 1.0 million bbl/d in 2013. Light crude imports averaged only 0.6 million bbl/d during the first two months of 2014 (Figure 2).

Furthermore, of the total 1.5 million bbl/d decline in crude oil imports between 2011 and 2013, nearly 25% was lighter than 40 API gravity. These imports fell from 0.6 million bbl/d in 2011 to 0.2 million bbl/d in 2013. Lighter than API 40 gravity crude imports averaged only 0.1 million bbl/d during the first two months of 2014.

Figure 2. U.S. crude oil imports by crude type

million barrels per day



Note: 2014 data include January and February only.
Source: U.S. Energy Information Administration, Petroleum Supply Monthly.

Other responses to the additional production of light oil over the past several years have included additional crude exports, an increase in the average gravity of crude inputs to domestic refining, and increased refinery runs, given the recent cost advantage of U.S. refiners relative to global competitors:

- U.S. exports of crude oil increased from 47,000 bbl/d in 2011 to 120,000 bbl/d in 2013 and averaged 244,000 bbl/d in first-quarter 2014.
- The average API gravity of crude oil run at U.S. refineries increased from 30.2 degrees in 2008 to 30.7 degrees in 2011 and to 30.8 degrees in 2013.
- Utilization at U.S. refineries increased from 86.2% in 2011 to 88.3% in 2013.

The dwindling amount of light crude imports available to be backed out through further like-for-like substitution, and the limits to increased utilization of existing refinery capacity that is already running at high rates, could cause absorption of further increases in domestic production to rely heavily on some combination of the following:

- Continued shifts in the refinery input mix, which can be enabled by investments to relieve constraints associated with running lighter crudes at refineries that were optimized to run heavier ones
- Added splitters to convert light crude into a mix of heavier fractions to feed domestic refineries and light products valued in other markets
- Continued increases in crude oil exports, which will depend in part on the extent of any relaxation of current export restrictions

All of these options have implications for the value of existing refineries and specific refinery units, given the substantial investments that many domestic refiners have made since the 1990s in coking capacity designed to process heavy crude. They also have implications for the mix of products produced by the refining sector, as well as the market value of each type of crude input and refinery product output. A further adjustment mechanism, a change in crude production, would come into play in the event that the market value of a particular type of crude or lease condensate reaches a level where production is not economic.

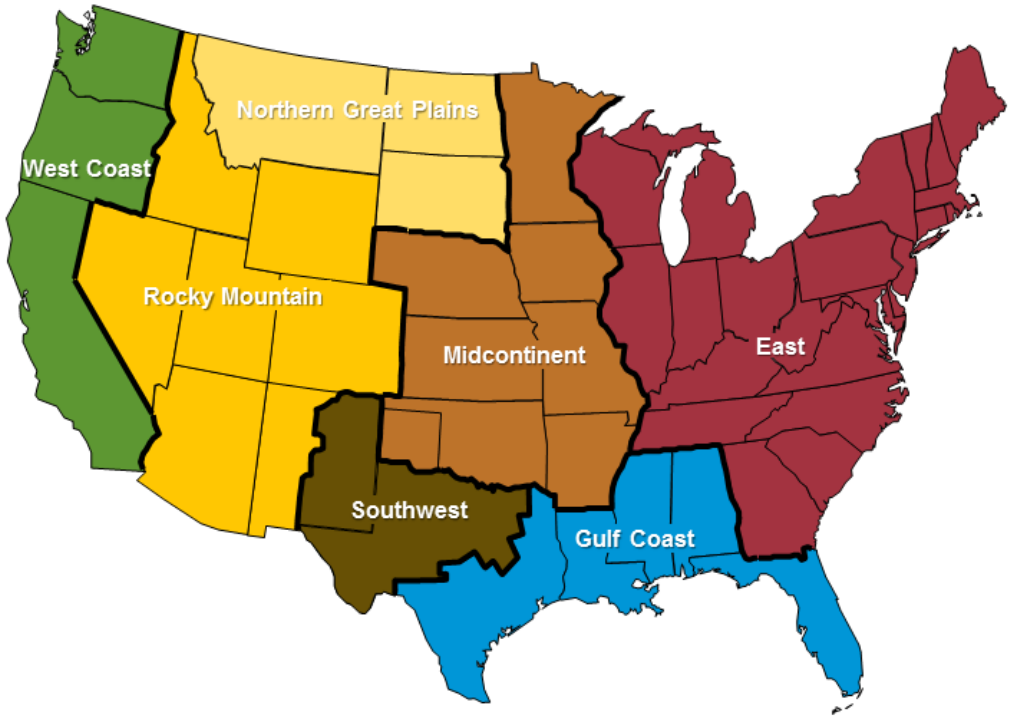
From the above discussion, it is evident that there are many issues for EIA to address in further analyses. But for now, we return to the focus of this paper by considering the forecast for crude production by type at the regional level.

Regional Analysis: Recent and Forecast Production by Crude Type

Regions and crude types

EIA analyzes U.S. crude oil production according to the regions shown on the map below. The producing regions are mapped to contain one or more hydrocarbon-producing geologic basins. In this paper, production is aggregated by crude types to regional totals.

Map 1. U.S. onshore lower-48 production regions

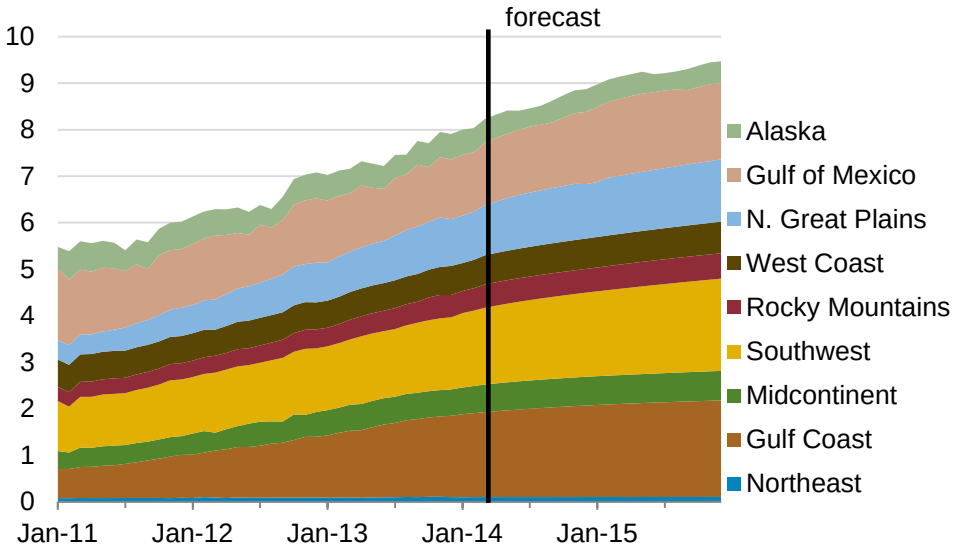


Source: EIA, Short-Term Energy Outlook.

In the May 2014 STEO, EIA forecast that U.S. crude oil production will grow from an average of 7.4 million barrels per day (bbl/d) in 2013 to 9.2 million bbl/d in 2015. The methodology for developing the forecast is explained in the February 2013 STEO Special Analysis article. Figure 3 below shows the regional components of the STEO crude oil production forecast.

Figure 3. U.S. crude oil production forecast

million barrels per day



Source: EIA, DrillingInfo.

There is no single standard classification scheme for grouping the large set of individual crude streams into a manageable number of categories for purposes of analysis. For this report, we categorized domestic production into 11 crude types. As shown in Table 1, the categories are based on API gravity ranges and sulfur content of produced oil. In some states where well-level data are available, crude oil production with API gravity between 40 and 50 can be separated into groups of API 40-45 and API 45-50, although sulfur content cannot be determined for these groups. Although additional API gravity data were not available for the Bakken, industry reports indicate that most Bakken wells produce relatively uniform quality crude oil between 40 and 45 degrees API gravity. The crude oil produced in California, primarily API<27 sour, is categorized separately because it is generally produced and refined in the same geographic region, and it is somewhat isolated from the heavy crude market dynamics of the rest of the country.

Data sources

Well-level production volumes are published by almost all states and are generally readily available, but the API gravity and sulfur content of that production are reported only by a few states. EIA has previously analyzed the characteristics of oil production at the basin level for the *Annual Energy Outlook*, and assigned crude types to production from different basins according to Table 1 below. In order to estimate the amount of production of different crude types for the STEO regional forecasts, the distribution of crude production from each region from the AEO2014 was applied to the STEO forecast for 2011 through 2015. Using well-level API gravity data where available – from the Railroad Commission of Texas for Eagle Ford and Permian production, and from the Colorado Department of Natural Resources for Niobrara production – Gulf Coast, Southwest, and Rocky Mountain regional production estimates were improved using data from wells completed as recently as March 2014.

Table 1. Crude oil types considered in this analysis

Chart Color	Crude Oil Type	API Gravity (degrees)	Sulfur Content (%)	a.k.a.
	API 50+	API>=50	<0.3	
	*API 45-50	45<=API<50	<0.3	
	*API 40-45	40<=API<45	<0.3	Light Sweet
	API 40-50 sweet	40<=API<50	<0.3	
	API 35-40 sweet	35<=API<40	<0.3	
	API 35-40 sour	35<=API<40	<1.1	Light Sour
	API 27-35 med-sour	27<=API<35	<1.1	Medium Medium Sour
	API 27-35 sour	27<=API<35	>=1.1	Medium Sour
	California	API<27	1.1-2.6	
	API<27 sweet	API<27	<1.1	Heavy Sweet
	API<27 sour	API<27	>=1.1	Heavy Sour

*Specified only where additional well-level API gravity data are available.

The quality and timeliness of well-level data on production by crude type used to develop the estimates vary widely across states. As part of its continuing effort to improve data on oil and natural gas production, EIA is now seeking public comment on a plan to expand its current collection of monthly natural gas production data in 6 states to include both oil and natural gas production in 21 states. The proposed data collection, which EIA plans to launch in 2015, would provide information on production by type. In addition to updates reflecting better data, updated estimates of regional production by crude type will likely be needed as new plays start commercial development. Production from new plays will change the distribution of production by crude types in the regions where those plays are located.

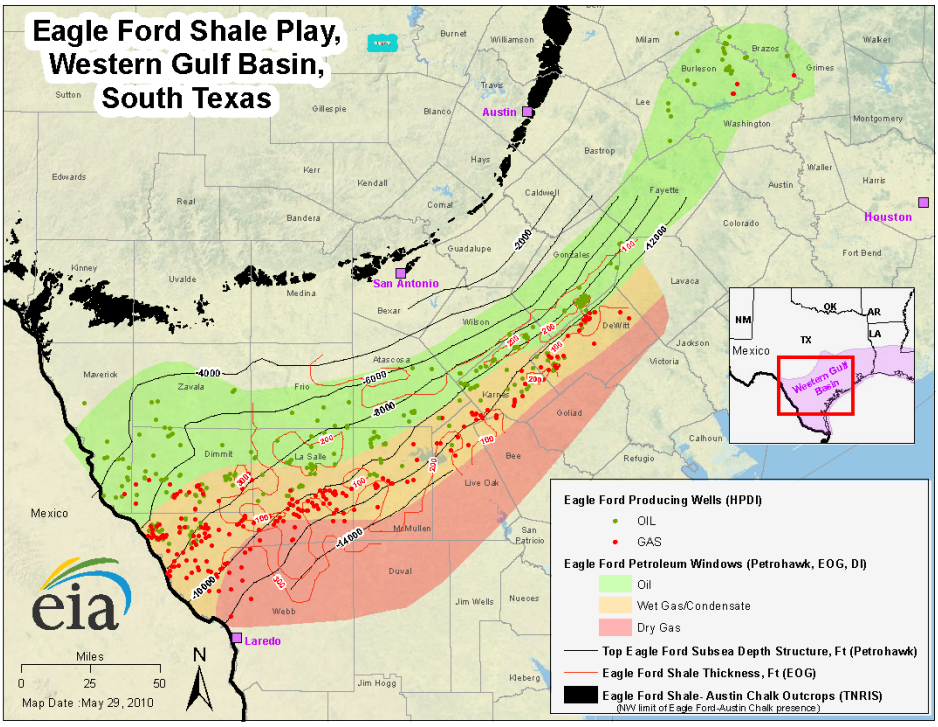
This paper estimates oil production by crude type as it would be delivered from well-site or lease storage tanks. Once the oil enters transportation and distribution systems, it may be commingled with other crude types (e.g., in rail cars or pipelines) or otherwise blended to capture economic opportunities before being delivered to the refinery. A simple example would be to blend relatively lower-value API<27 with API 50+ oil if the price of selling API 35-40 oil exceeded the cost of buying and blending the inputs. To the extent that such blending occurs, the volume of some crude oil types received by refineries would be different from those estimated from the well-level analysis in this paper.

A final point to consider involves the distinction between the very light grades of lease condensate (which are included in EIA's oil production data) and hydrocarbon gas liquids (HGL) that are produced from the wellhead as gas but are converted to liquids once separated from methane at a natural gas processing plant. These hydrocarbons include ethane, propane, butanes, and hydrocarbons with five or more carbon atoms – referred to as pentanes plus, naphtha, or plant condensate. Plant condensate can also be blended with crude oil, which would change both the distribution and total volume of oil received by refineries.

Eagle Ford and Gulf Coast: Recent and forecast production by crude type

The Eagle Ford is somewhat unique compared to other key oil-producing plays as there are three relatively distinct "windows" of the play. The formation becomes deeper moving from northwest to southeast, creating an oil window, a condensate window, and a dry gas window. Since 2010, producers in the Eagle Ford have moved steadily towards areas with more liquids, as prices have continued to favor oil over natural gas (see Today In Energy, February 10, 2014).

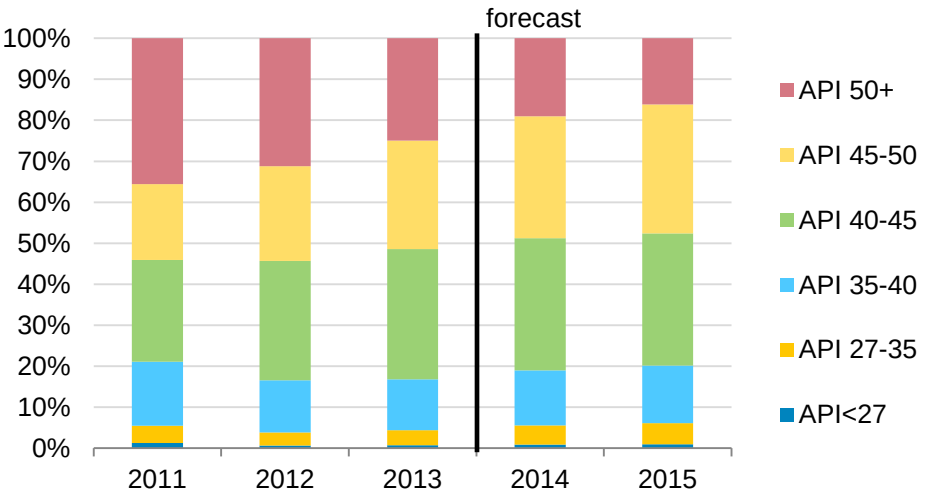
Map 2. Eagle Ford Shale Play



Source: EIA, http://www.eia.gov/oil_gas/rpd/shaleusa9.pdf.

This shift is also reflected in Figure 4, where a large percentage of Eagle Ford production in 2011 came from wells with reported API gravity greater than 50 degrees, but a greater share of the production growth in the subsequent two years came from new wells with reported API gravity between 40 and 50 degrees. The shift to producing oil rather than natural gas will continue in 2014 and 2015 based on the forecast for crude oil prices to remain high relative to natural gas prices.

Figure 4. Annual distribution of Eagle Ford production

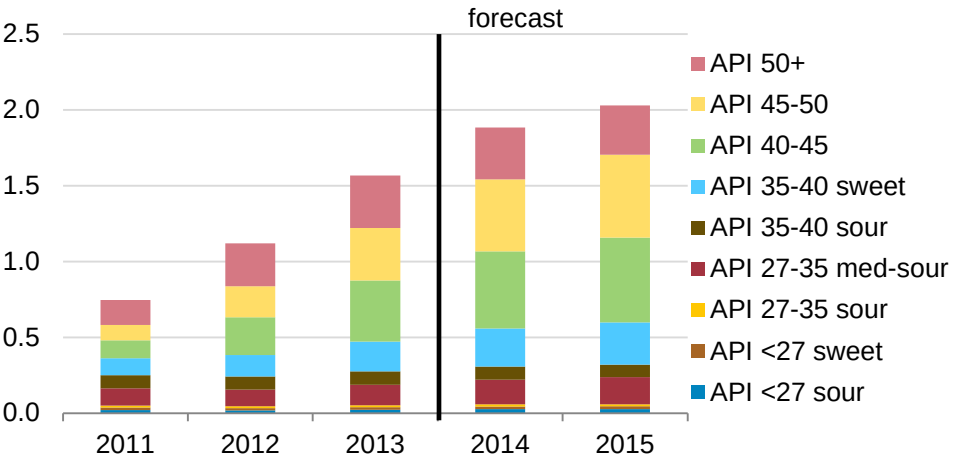


Source: EIA, DrillingInfo, Texas RRC.

Eagle Ford makes up nearly all the tight oil production in the Gulf Coast region. Adding in the residual tight oil production from Haynesville (approximately 50,000 bbl/d) and the stable non-tight Gulf Coast oil production (approximately 450,000 bbl/d), distributed into crude types by the *Annual Energy Outlook* projections, results in the total Gulf Coast production forecast shown in Figure 5.

Figure 5. Gulf Coast crude oil production by crude type

million barrels per day

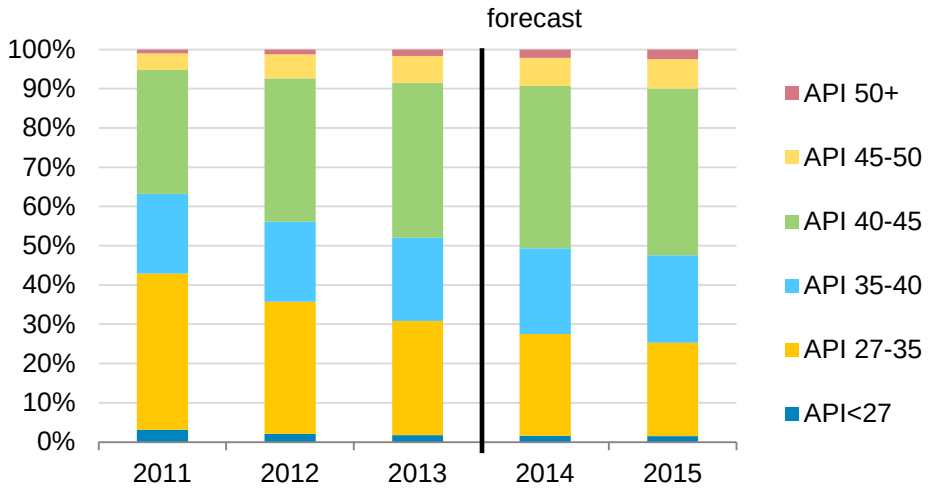


Source: EIA, DrillingInfo, Texas RRC.

Permian and Southwest: Recent and forecast production by crude type

Virtually all oil production in the Southwest region comes from the Permian basin. Permian oil production averaged 1.3 million bbl/d in 2013, compared to 100,000 bbl/d from the rest of the Southwest region. EIA analysis of Railroad Commission of Texas well records shows production by crude type changing rapidly, as new drilling in the basin increasingly targets the various stacked tight oil formations, rather than the conventional oil formations that have been developed for decades (Figure 6).

Figure 6. Annual distribution of Permian production

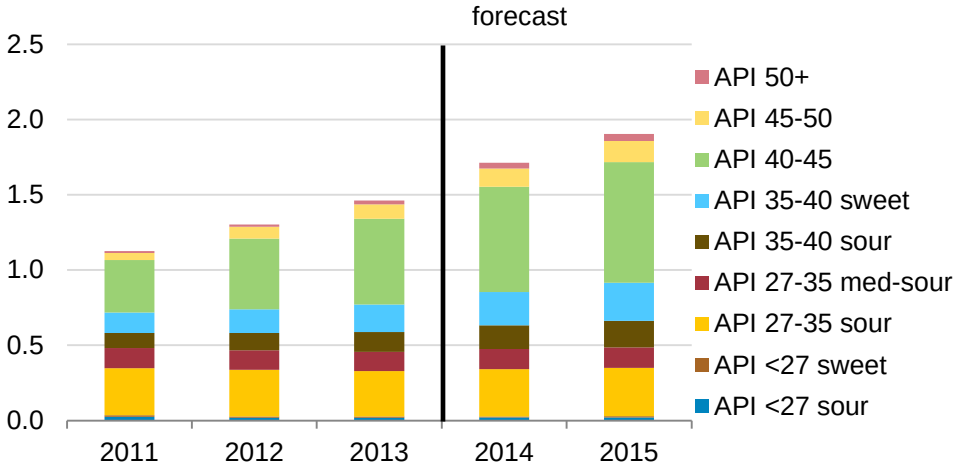


Source: EIA, DrillingInfo, Texas RRC.

EIA expects this trend to continue in 2014 and 2015, as Permian oil production is forecast to reach an annual average 1.8 million bbl/d in 2015, and other Southwest production is forecast to fall to 66,000 bbl/d in 2015, for a total of 1.9 million bbl/d oil production in the Southwest region (Figure 7).

Figure 7. Southwest crude oil production by crude type

million barrels per day

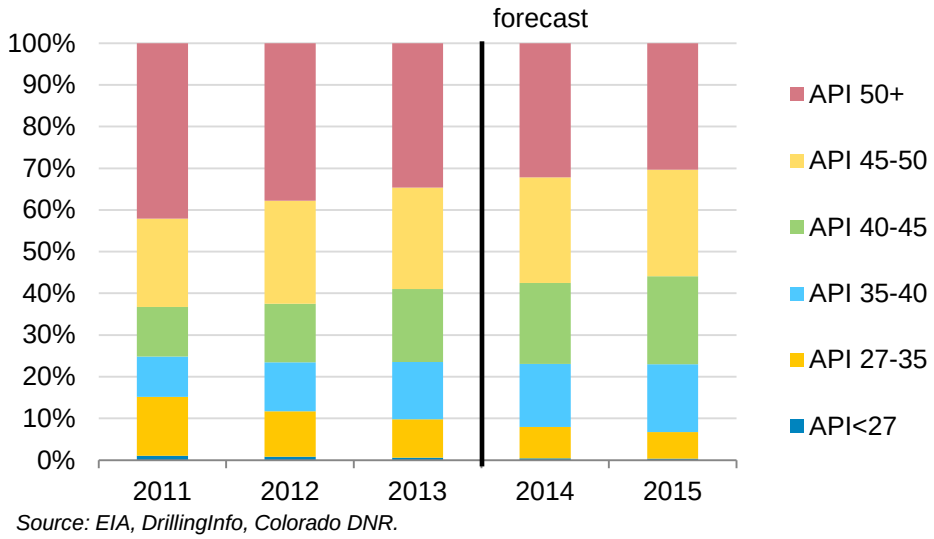


Source: EIA, DrillingInfo, Texas RRC.

Niobrara and Rocky Mountains: Recent and forecast production by crude type

The Rocky Mountains region is a significant producer of natural gas, although natural gas production has been declining in recent years as high oil prices and recent drilling success in the Niobrara formation have steered producers towards oil production. The distribution of Niobrara area oil production (Figure 8) reflects this, showing a significant but diminishing percentage of API 50+ production, which is commonly produced from wells targeting natural gas. Over the forecast period, production of oil with API gravity between 35 and 50 degrees expands to more than 60% of total oil production. Rocky Mountains oil production surpasses an average of 500,000 bbl/d in 2014 (Figure 9).

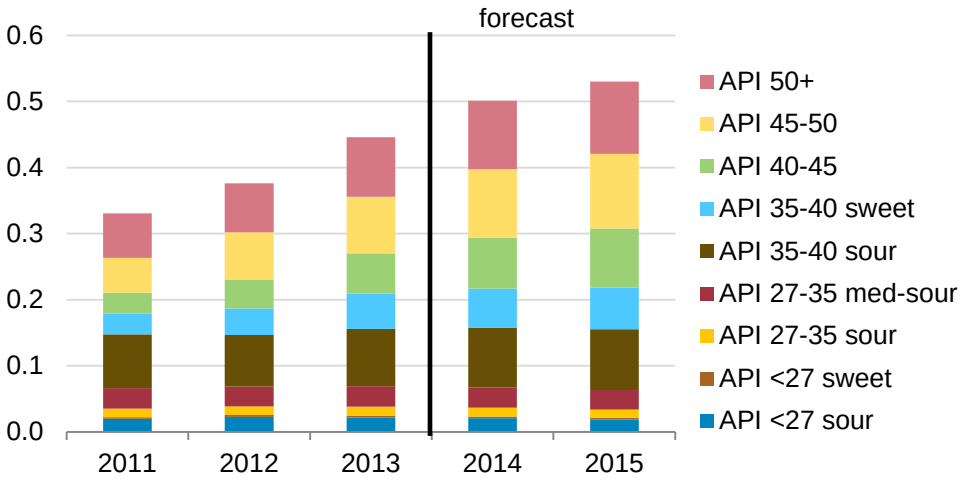
Figure 8. Annual distribution of Niobrara production



Source: EIA, DrillingInfo, Colorado DNR.

Figure 9. Rocky Mountains crude oil production by crude type

million barrels per day

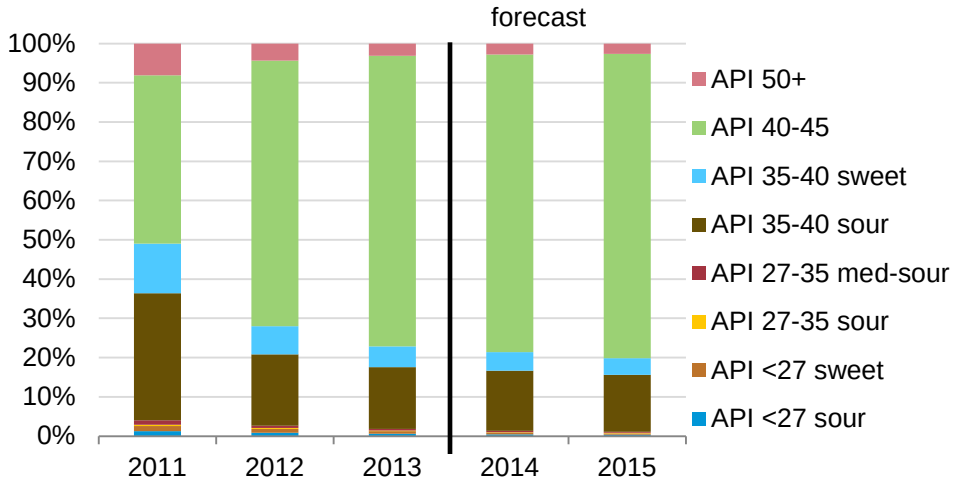


Source: EIA, DrillingInfo, Colorado DNR.

Northern Great Plains: recent and forecast production by crude type

Oil production growth in the Northern Great Plains region is expected to continue primarily from the Bakken. Although additional API gravity data were not available from the North Dakota Industrial Commission, industry reports indicate that Bakken crude oil consistently measures between 40 and 45 degrees API gravity. As such, the *Annual Energy Outlook* API 40-50 percentage of Northern Great Plains oil production was recategorized as API 40-45 for this analysis.

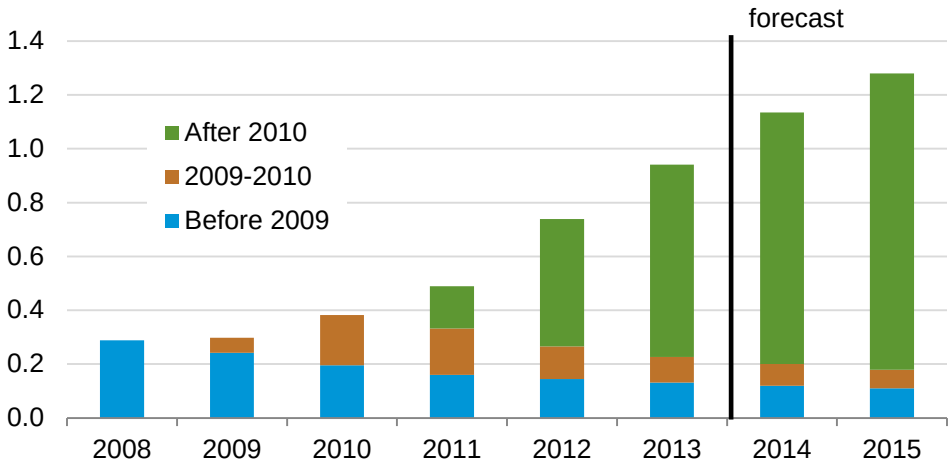
Figure 10. Annual distribution of Northern Great Plains production



Source: EIA, DrillingInfo.

Bakken oil production began increasing in 2009 and 2010, but there was nearly 300,000 bbl/d of legacy oil production from conventional reservoirs in the Northern Great Plains region. Figure 11, which shows oil production grouped by the year wells started producing, provides context to the distribution of oil production by crude type in Figure 10.

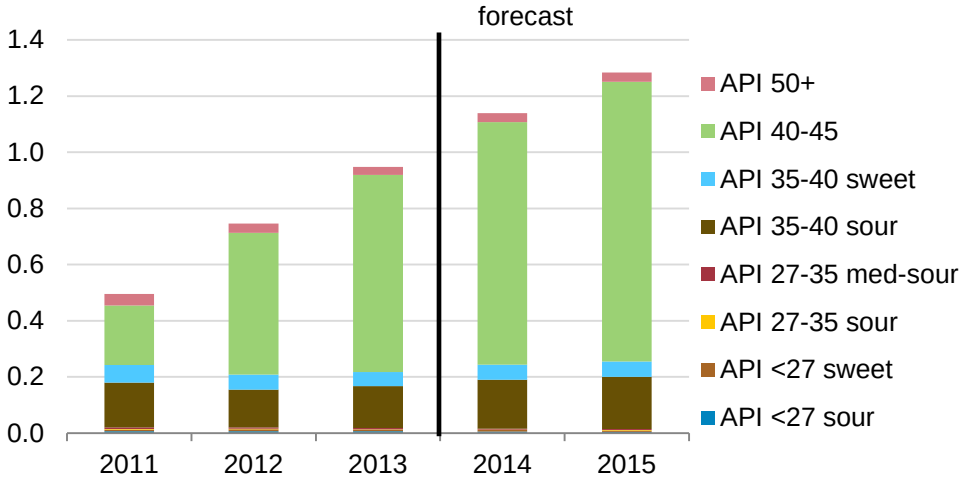
Figure 11. Northern Great Plains crude oil production by well start date



Source: EIA, DrillingInfo.

Northern Great Plains crude oil production is forecast to average 1.3 million bbl/d in 2015, almost 80% of which has API gravity between 40-45 degrees (Figure 12).

Figure 12. Northern Great Plains crude oil production by crude type

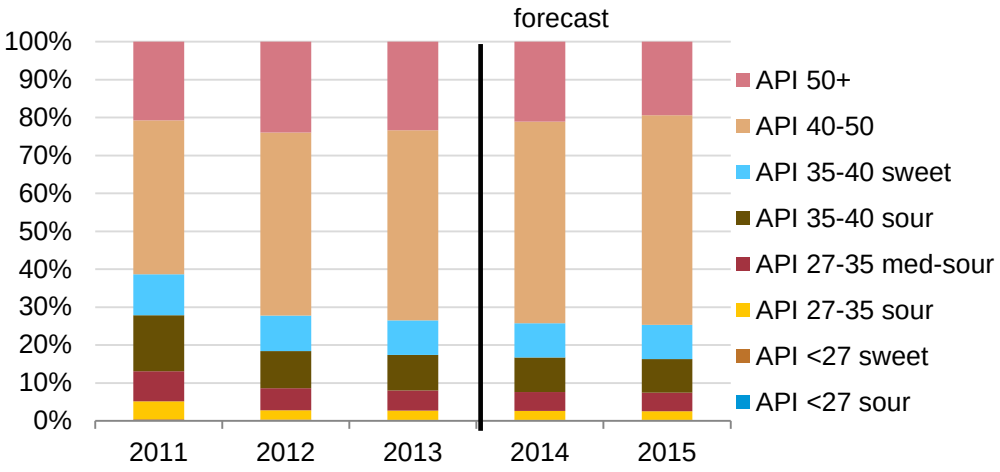


Source: EIA, DrillingInfo.

Midcontinent: Recent and forecast production by crude type

Well-level API gravity data from Oklahoma and Kansas were not available to examine the crude oil quality from formations such as the Granite Wash and Woodford. Based on the *Short-Term Energy Outlook* production forecast and the *Annual Energy Outlook* crude type distribution, Midcontinent crude oil production is forecast to increase from 560,000 bbl/d in 2013 to 625,000 bbl/d in 2015, with API gravity 40-50 crude oil making up 55% of the 2015 estimate (Figures 13 and 14).

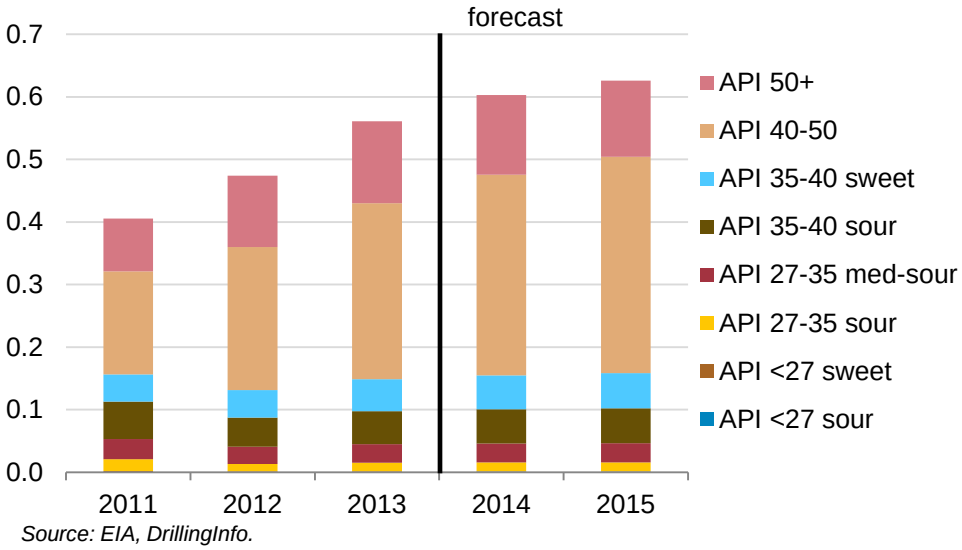
Figure 13. Annual distribution of Midcontinent production



Source: EIA, DrillingInfo.

Figure 14. Midcontinent crude oil production by crude type

million barrels per day



Source: EIA, DrillingInfo.

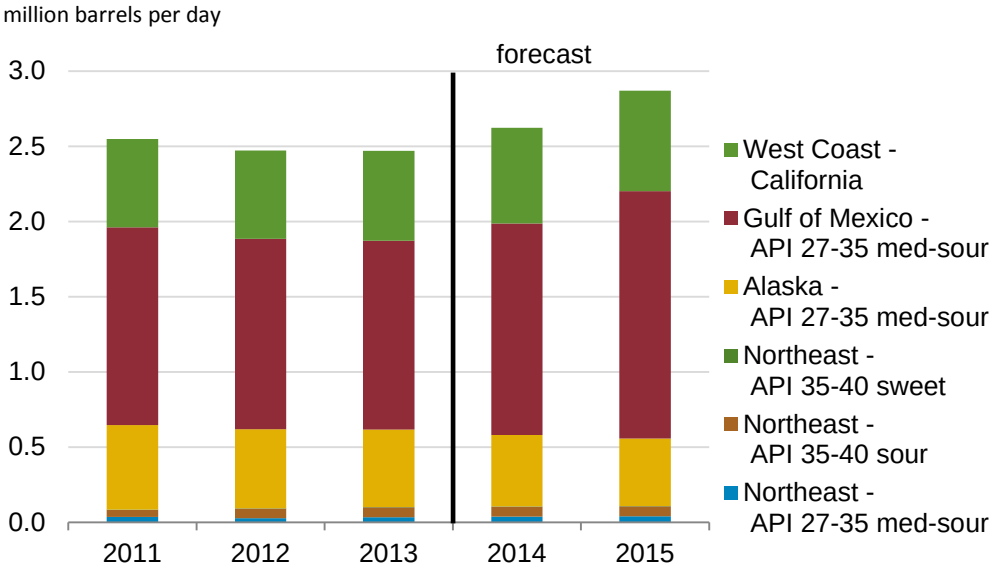
Alaska, Gulf of Mexico, Northeast, and West Coast: Recent and forecast production by crude type

In the *Annual Energy Outlook* crude type estimates, all Alaska and Gulf of Mexico oil production is assumed to be API gravity 27-35 degrees and medium sour. Northeast crude oil production consists of approximately 30% API 27-35 medium-sour and 60% API 35-40 sour. The residual production is API 35-40 sweet. West Coast region production, coming from California, is primarily API<27 sour. Per the "Regions and crude types" discussion above, California production is categorized by its own crude type.

Based on forecasts of annual average production from 2013 to 2015 in the *Short-Term Energy Outlook*:

- Alaska production declines from 515,000 bbl/d to 450,000 bbl/d
- Gulf of Mexico production increases from 1.3 million bbl/d to 1.6 million bbl/d
- Northeast production increases slightly from 100,000 bbl/d to 110,000 bbl/d
- West Coast production increases from 600,000 bbl/ to 670,000 bbl/d (Figure 15)

Figure 15. Alaska, Gulf of Mexico, Northeast, West Coast crude oil production



Source: EIA, DrillingInfo.