RYSTAD ENERGY

COVID-19 REPORT

SCENARIOS AND IMPACT ON GLOBAL ENERGY MARKETS

11 MARCH 2020

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Executive summary

In a matter of weeks the novel coronavirus has proliferated into a world-wide pandemic, challenging government institutions and testing society and the global economy.

What follows in this report is the application of our data modeling expertise, as applied to the spread of novel coronavirus and its effect on global oil demand. Our analyses have illuminated four primary areas of insight, which are expanded upon in detail throughout the report:

Our simulations indicate that **only effective quarantine measures are able to halt an outbreak** that has surpassed a certain threshold, as can be seen in our simulations for China, South Korea, and Italy.

Depending upon the swiftness of quarantine implementation, **it appears that the spread of an outbreak may be halted after 5 to 20 weeks of quarantine**. South Korea and China appear at the low end of this interval, while Italy appears at the high end. Warmer weather is also likely to reduce the transmission rate of the virus, which may result in decreased quarantine time.

Road traffic and aviation appear to have been greatly affected by the spread of the virus and subsequent quarantine measures. We posit that other market segments will be indirectly affected as a function of the slowdown in global GDP growth. In sum, the aggregated demand destruction from areas outside of China is likely to be larger than the total demand destruction from China itself.

Quarantine measures in China and elsewhere appear to have **reduced global oil demand by as much as 1.8 million barrels per day (bpd) in the first quarter.** We expect to see further demand destruction in Europe, the Middle East and North America as quarantine initiatives are implemented in March in Italy, throughout Europe in April, and throughout North American in May. This may result in a **3 million bpd reduction in global oil demand for the second quarter relative to pre-virus forecasts.**

Rystad Energy is an energy knowledge house, and thus does not possess medical expertise. So **why are we addressing the COVID-19 spread?** The answer is simple; accurately modelling virus spread can be understood through the application of mathematics, drawing upon observed epidemiological data from consensus institutions such as the WHO. Our advanced analytical tools have already been utilized to create a system dynamics model of global oil price fluctuations, and applying the same tools to the COVID-19 situation allows us to build a very sophisticated model of the virus spread. This independent viewpoint provides unique insight into the behavioral changes that follow measures such as quarantines and aviation restrictions – information which has not been available from other sources – and informs our assessment of the impact on global energy markets.

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Executive Summary

Outbreak scenarios and effect of preventative measures

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Outlook for the impact on the energy sector

Methodology

Scenario definitions

This regular report addresses the novel coronavirus situation through three possible scenarios, hinging upon one key factor – the probability of transmitting the virus between individuals. This can be understood as the number of interactions per person per day over a given time frame, multiplied by the probability that each contact will transmit the virus to the other persons. We assume a basic reproduction number of 2.1, meaning that one infected individual will pass novel coronavirus, or COVID-19, to 4% of the 10 people they interact with over the course of one day. We also assume this will occur over 5.2 days, until they are aware they have become infected and change their behavior.

The precise virility of COVID-19 remains unclear, subject to a variety of yet-unknown variables. Nevertheless, if the virus behaves similarly to its cousin influenza A, we can assume that warmer weather will reduce the rate of transmission. All scenarios therefore incorporate the possibility of the "spring effect", meaning that seasonal warming would help decrease COVID-19 transmission.

In our medium spread scenario entitled "**Less Effective Prevention**", we consider "prevention" as the implementation of quarantines and other effective methods of social distancing. In this scenario we assume that quarantines are implemented, but are loosened prematurely or have marginal compliance.

The **Effective Prevention** scenario offers a more hopeful outlook, plotting the spread of COVID-19 under the assumption that the majority of countries implement effective preventative measures, which are considered to be a strict and lasting quarantines.

Both of these scenarios consider two categories of quarantine, an effective or **strict quarantine**, versus a weak or **"half-hearted" quarantine**. A strict quarantine means that contact rates have fallen to 1, or interaction with only one other person over the course of one day. A "half-hearted" quarantine means a quarantine that exhibits weak compliance, resulting in a contact rate of four – lower than a normal contact rate of 10, but still not low enough to completely halt the spread of COVID-19.

Red tones
Includes those that understand they are infected and/or behave as if they were infected. This group complies with preventative measures and exhibit low transmissibility once diagnosed.

Blue tones
Includes those who do not understand they are infected or do not behave as if they were infected. This group does not comply with preventative measures and exhibit high transmissibility if infected.

Hospital treatment and critical
Those who are admitted to a hospital for treatment, including fatalities.

Minor symptoms
Those who either have been diagnosed, or suspect they may be infected and behave accordingly

Reported recovered
Those who have recovered after a known infection

Infected, undiagnosed
Those who are infected but have not been diagnosed and do not behave as if they were infected

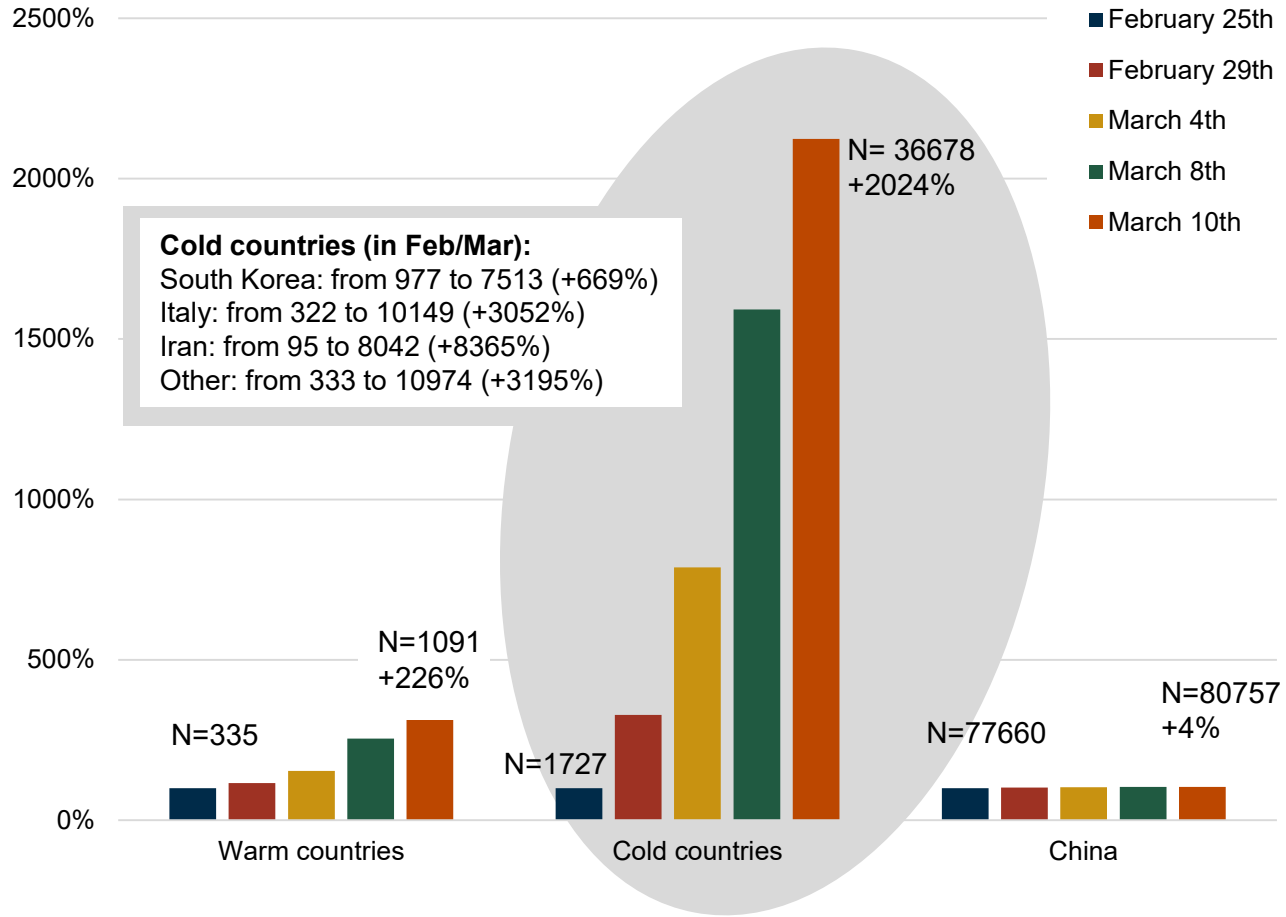
Recovered, undiagnosed
Those who have recovered without ever realizing they were infected.

Reported cases
Official reported cases of COVID-19 infection

Colder countries exhibit higher cases of COVID-19

Percent increase
Scaled to 25 February numbers

Time period:
25 February – 10 March



Registered cases of COVID-19 exploded in cold countries from 25 February to 10 March.

- We have separated countries into two categories: warm countries and cold countries, meaning those exhibiting morning and evening temeraptures above or below 10°C in February.
- Reported cases of COVID-19 have increased almost 20-fold in cold countries since 25 February. In warm countries, this increase was 226%, and only 4% in China.
- Most cases in both warm and cold countries thus far appear to be from individuals travelling from infected areas.
- However, in cold countries new cases have exploded.
- Flu epidemics typically spread in the winter and die out in the spring. One theory is that droplets from breath or coughing are smaller and spread more easily in cold, dry air. Still it is too early to conclude whether COVID-19 follows the same pattern, but the figures as shown here illustrate a clear connection between temperature and spread.
- Wuhan, China had an average minimum temperature of 0°C degrees from January 8th to 18th, when virus cases exploded. In February the average minimum temperature increased to 6°C. Still, stringent quarantine measures undoubtedly contributed most to the slower spread of the virus in China in February.

Cold countries: Afghanistan, Albania, Algeria, Andorra, Armenia, Austria, Azerbaijan, Bahrain, Belarus, Belgium, Bhutan, Bosnia and Herzegovina, Bulgaria, Canada, Croatia, Czech Republic, Denmark, Estonia, Faroe Islands, Finland, France, Georgia, Germany, Greece, Hungary, Iceland, Iran, Iraq, Ireland, Israel, Italy, Japan, Jordan, Kuwait, Latvia, Lebanon, Liechtenstein, Lithuania, Luxembourg, Malta, Mexico, Moldova, Monaco, Mongolia, Nepal, Netherlands, New Zealand, Nigeria, North Macedonia, Norway, Oman, Pakistan, Poland, Republic of Ireland, Romania, Russia, San Marino, Serbia, Slovakia, Slovenia, South Korea, Spain, Sweden, Switzerland, UK, Ukraine, US, Vatican City

Warm countries: Argentina, Australia, Bangladesh, Brazil, Brunei, Burkina Faso, Cambodia, Cameroon, Chile, Costa Rica, Dominican Republic, Egypt, French Guinea, Gibraltar, Hong Kong, India, Indonesia, Macau, Malaysia, Maldives, Martinique, Palestine, Panama, Paraguay, Philippines, Qatar, Saint Barthelemy, Saint Martin, Saudi Arabia, Senegal, Singapore, South Africa, Sri Lanka, Taiwan, Thailand, Togo, United Arabic Emirates, Vietnam

Source: Rystad Energy; Johns Hopkins Center for Systems Science and Engineering (CSSE); Worldometer

China

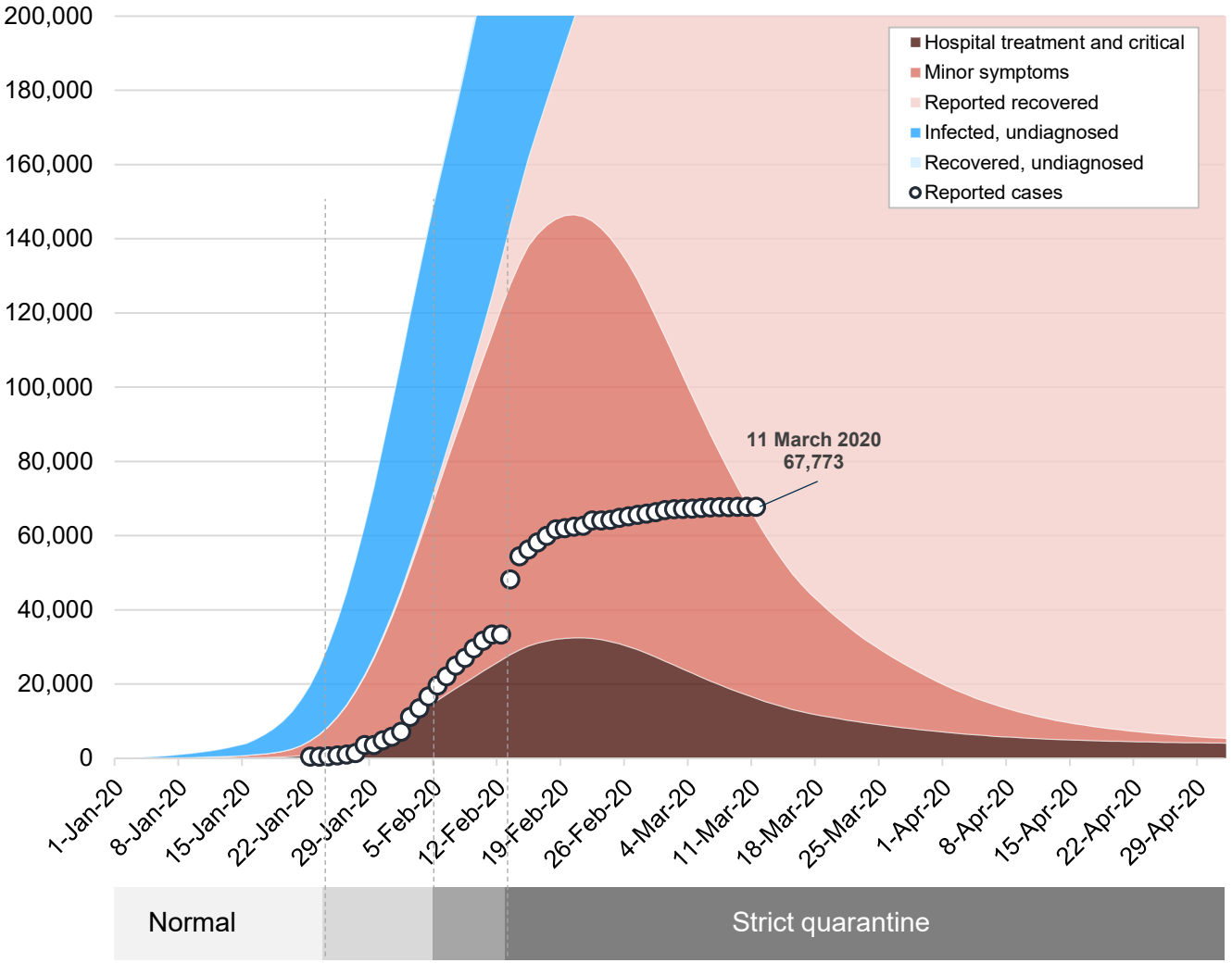
Recent figures show that the spread of COVID-19 has slowed to a halt, with very few new cases in recent days. In Hubei province, primarily in the city of Wuhan, quarantine measures have been extremely effective. Rystad Energy estimates that close to 355,000 people have likely been infected, although only 68,000 have been reported to have the virus after being tested. Most have now recovered after eight weeks of quarantine. Risk remains of a new outbreak if quarantine measures are loosened prematurely. Outside Hubei, approximately 13,000 have tested positive for the virus, of which 110 cases have proven fatal.

China, Hubei

The benchmark for an Effective Prevention Scenario

Reported and potential total COVID-19 cases by disposition
Number of individual cases

Time period:
1 January – 1 May



Source: Rystad Energy research and analysis; Reported cases from Worldometer.

While reported cases stand at only been 68,000, our simulation shows that the cases of infection likely peaked on 20 Feb at 146,000, with 32,500 in need of hospital treatment – four weeks after the first preventive measures were introduced.

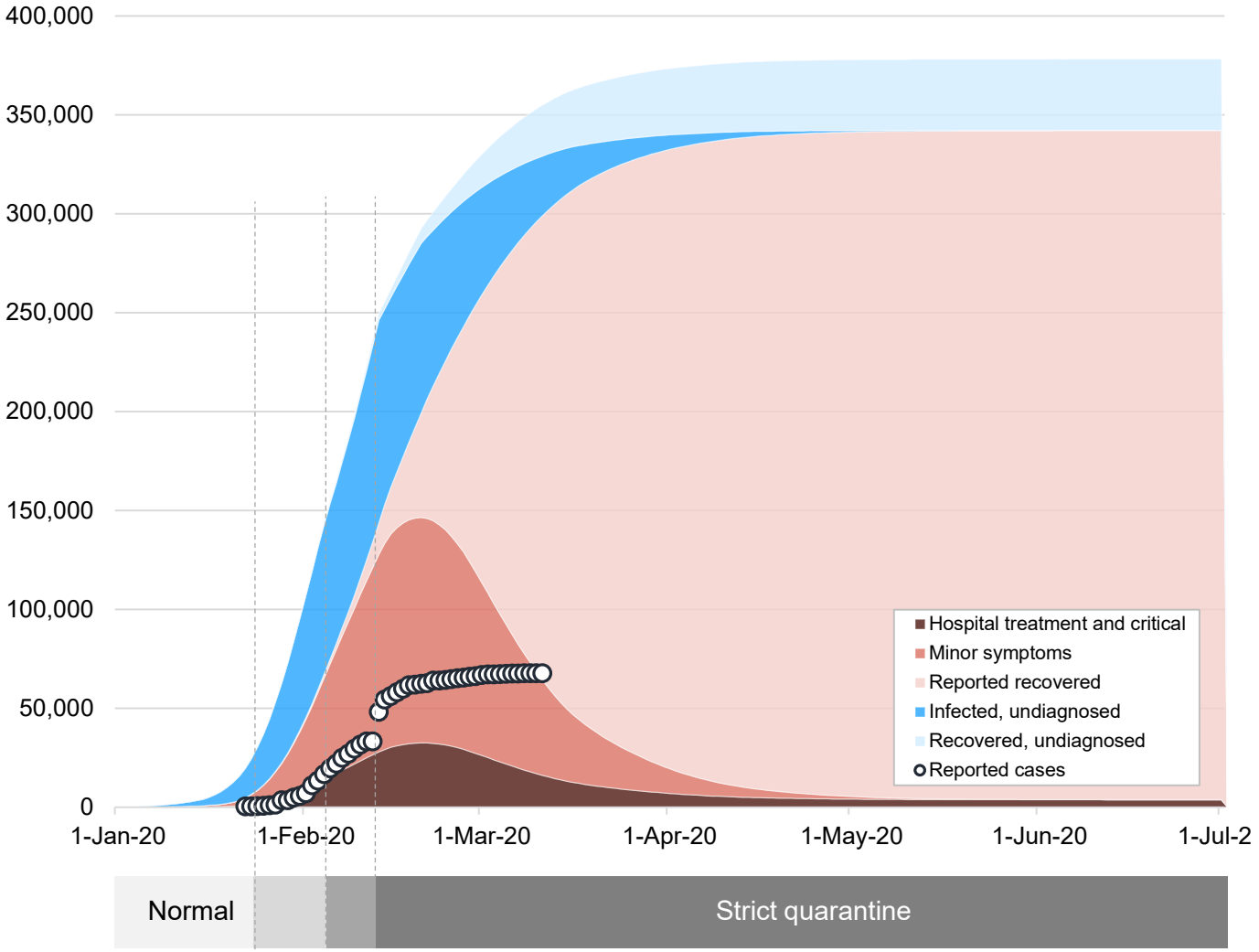
- In the most Effective Prevention simulation for Hubei, China is calibrated to the current number of reported fatalities, which is 3,158. We have assumed a fatality rate of 1%, similar to what is observed for South Korea.
- With the implementation of strict quarantine measures on 23 January, we assume the rate of interactions gradually fell from interactions with 10 other people per day to just 3.5 interactions.
- The number of contact points then fell further to 1.5 after non-essential companies were shut down on 13 February, declining to one after all schools were closed on 20 February.
- Our results indicate that the initial count of registered cases included hospital cases only. The methodology for official infection confirmation was revised by the Chinese government on 12 February, thus explaining the jump between 12 Feb and 14 Feb.

China, Hubei

Number of new cases will likely continue to decline if quarantine is not lifted prematurely

Reported and potential total COVID-19 cases by disposition
Number of individual cases

Time period:
1 January – 1 July



The rate of infection in Hubei is now showing strong decline following efficient government quarantine measures.

- This is supported by recent reports of temporary hospitals in Wuhan being closed.
- Even though the number of new cases is declining, the model predicts some new cases will appear throughout May, illustrating the risk of lifting quarantine measures prematurely.
- The total number of infected people will be limited to 374,000 if contact between people is kept at one contact point per person per day until 1 May. Of those, we expect 36,000 may recover without symptoms, with an additional 300,000 recovering without ever having been tested or reported.

Source: Rystad Energy research and analysis; Reported cases from Worldometer.

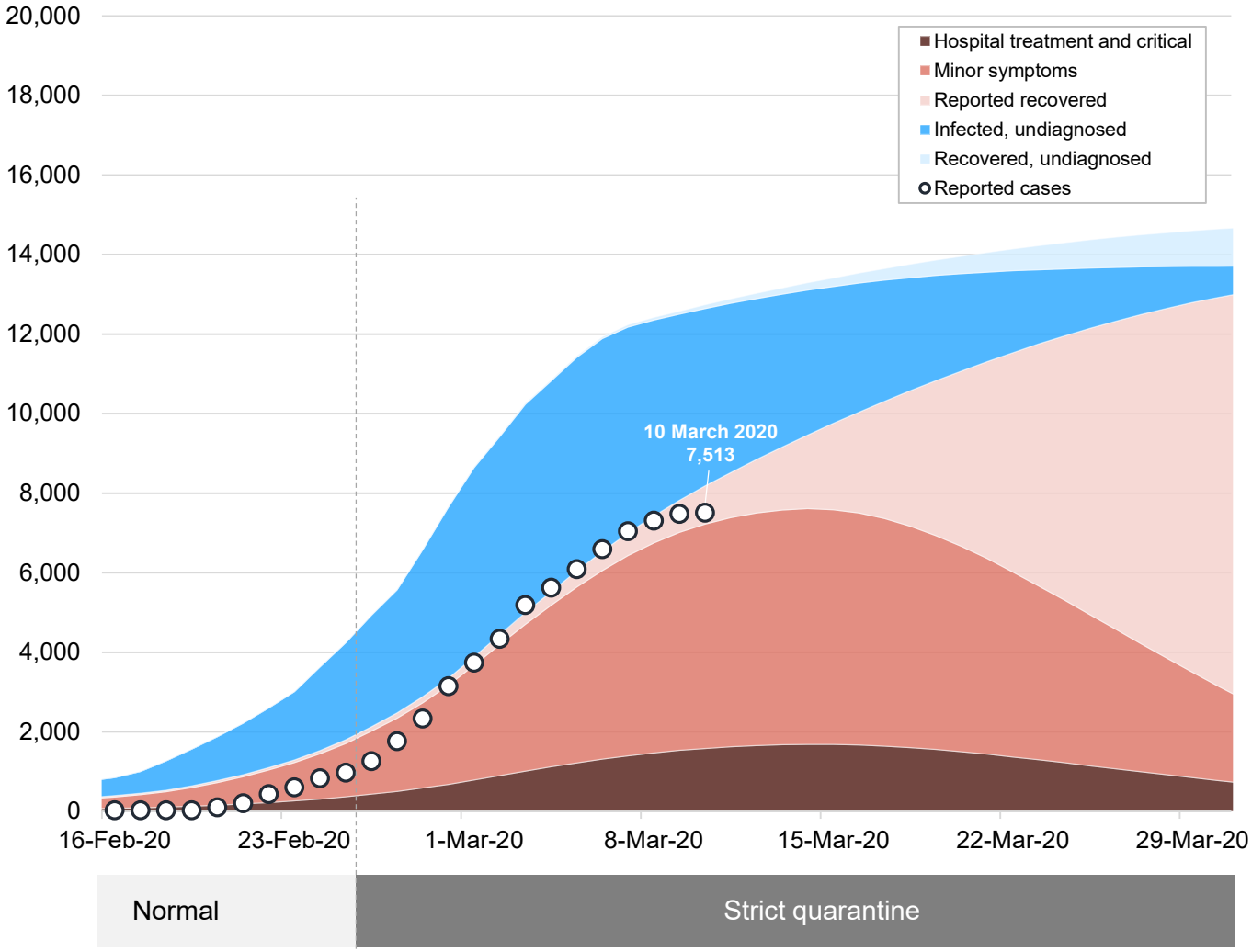
South Korea

Recently reported figures indicate that the spread of COVID-19 is under control in South Korea thanks to very effective quarantine measures and extensive testing, with Daegu and Gyeongbuk provinces exhibiting the most cases. The country reports approximately 7,500 confirmed infections out of around 200,000 individuals tested. Of this number, only 58 cases have proven fatal.

Effective prevention should result in outbreak containment by May 1st

Reported and potential total COVID-19 cases by disposition
Number of individual cases

Time period:
16 February – 30 March



Within our Effective Prevention Scenario, total confirmed cases will approach 15,000, with the spread of the outbreak essentially halted by 1 May. Given these parameters, we assume hospitalized and critical cases could peak on 16 March at 1,700 cases.

- In South Korea the number of reported cases has increased from 31 on 20 February to 7,513 10 March. Of these cases, 90% are in the urban area of Daegu and Gyeongbuk.
- South Korea exhibits one of the highest rates of testing globally, with more than 110,000 people tested at the beginning of March, and likely another 100,000 since then. Compared to other geographical areas, we expect figures for recovered and asymptomatic individuals (those unaware of being infected) will be low in South Korea.
- In this Effective Prevention Scenario simulation, we assume the daily contact rate for an infected, but unaware, person was 12* until 27 February, at which point we believe the daily contact rate plummeted to one due to effective quarantine measures which will last until end of March.
- According to this model, no new regions in South Korea will have a major outbreak. We also assume that mild weather in April will decrease transmissibility to zero.

Source: Rystad Energy research and analysis; Reported cases from Worldometer. *The contact rate has been increased to 12 rather than 10 as the first outbreak was connected to a closed group of people, the Shincheonji religious sect.

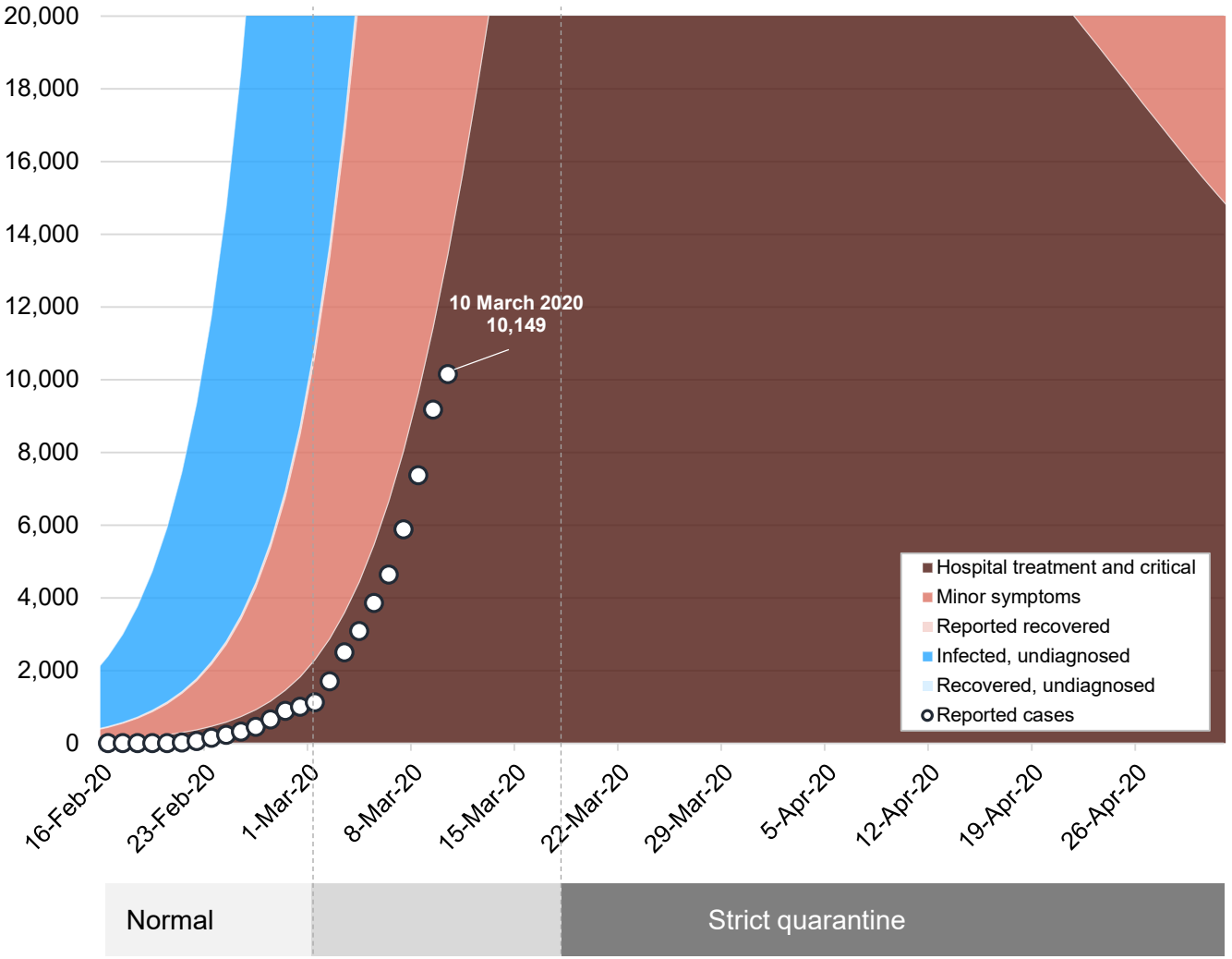
Italy

After a period of chaos, the Italian government is now taking stringent steps towards gaining control, placing the entire country under quarantine. According to our estimate, at least 250,000 people are likely already infected, most of whom are unaware they are infected. If the quarantine can successfully reduce the number of contact points to one per person per day, and last until 1 June, then 29 March may be the point of peak infection, with approximately 200,000 actively ill, out of which 45,000 will require hospitalization. If quarantine measures are half-hearted, our models indicate that millions of people will be infected, with hundreds of thousands requiring medical attention at a hospital.

Total infected population may now have reached 250,000

Reported and potential total COVID-19 cases by disposition
Number of individual cases

Time period:
February 16 – May 1



We expect the real number of infected people In Italy was approximately 50,000 as of 1 March, and 250,000 as of 10 March.

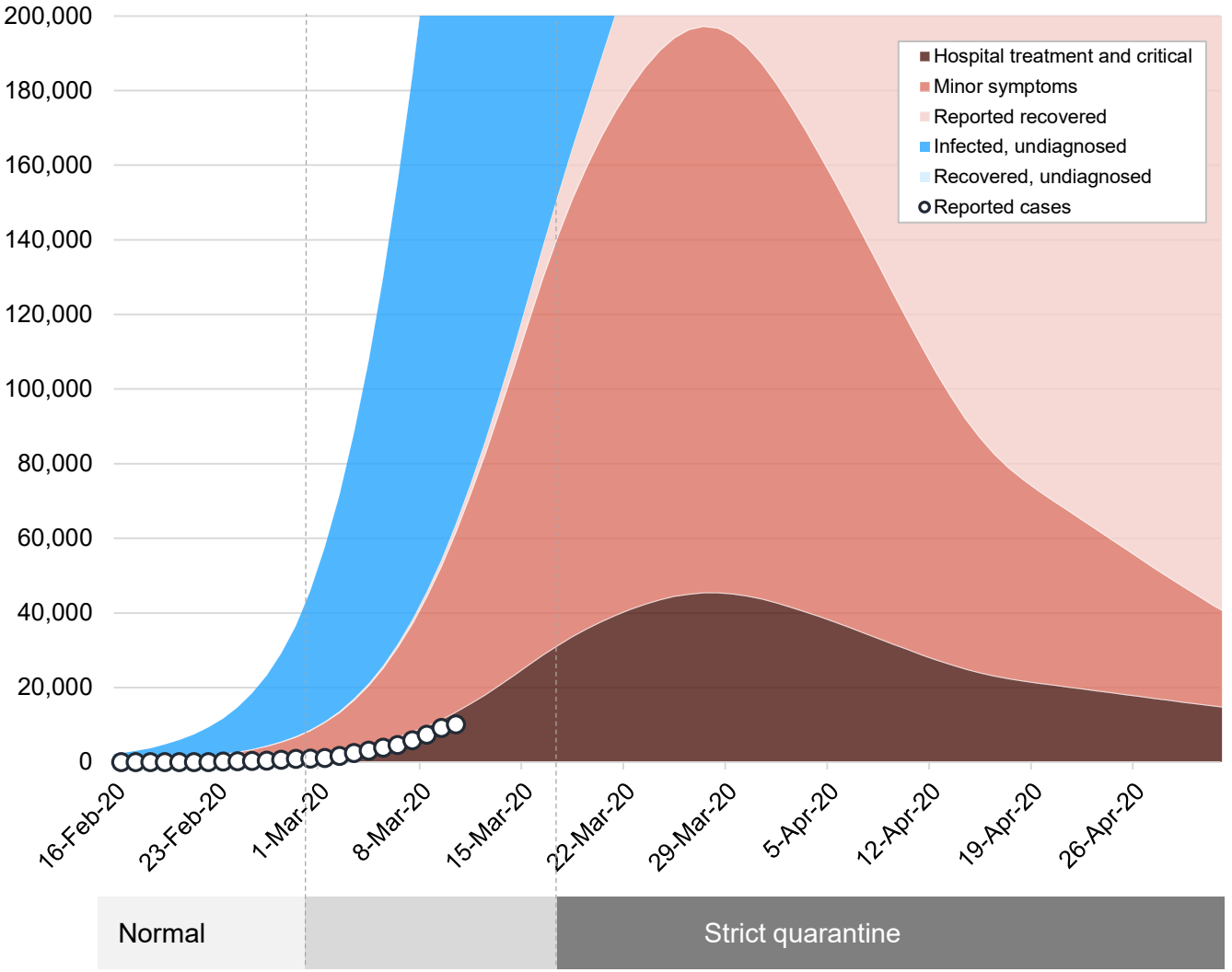
- The most Effective Prevention simulation for Italy is calibrated to fit the current number of reported fatalities, which is about 631. We have then used a similar fatality rate as for South Korea, around 1%.
- With this in mind, it seems that only hospital cases have been counted as registered cases in Italy.

Source: Rystad Energy research and analysis; Reported cases from Worldometer.

Effective prevention could limit the outbreak to a peak late March

Reported and potential total COVID-19 cases by disposition
Number of individual cases

Time period:
February 16 – May 1



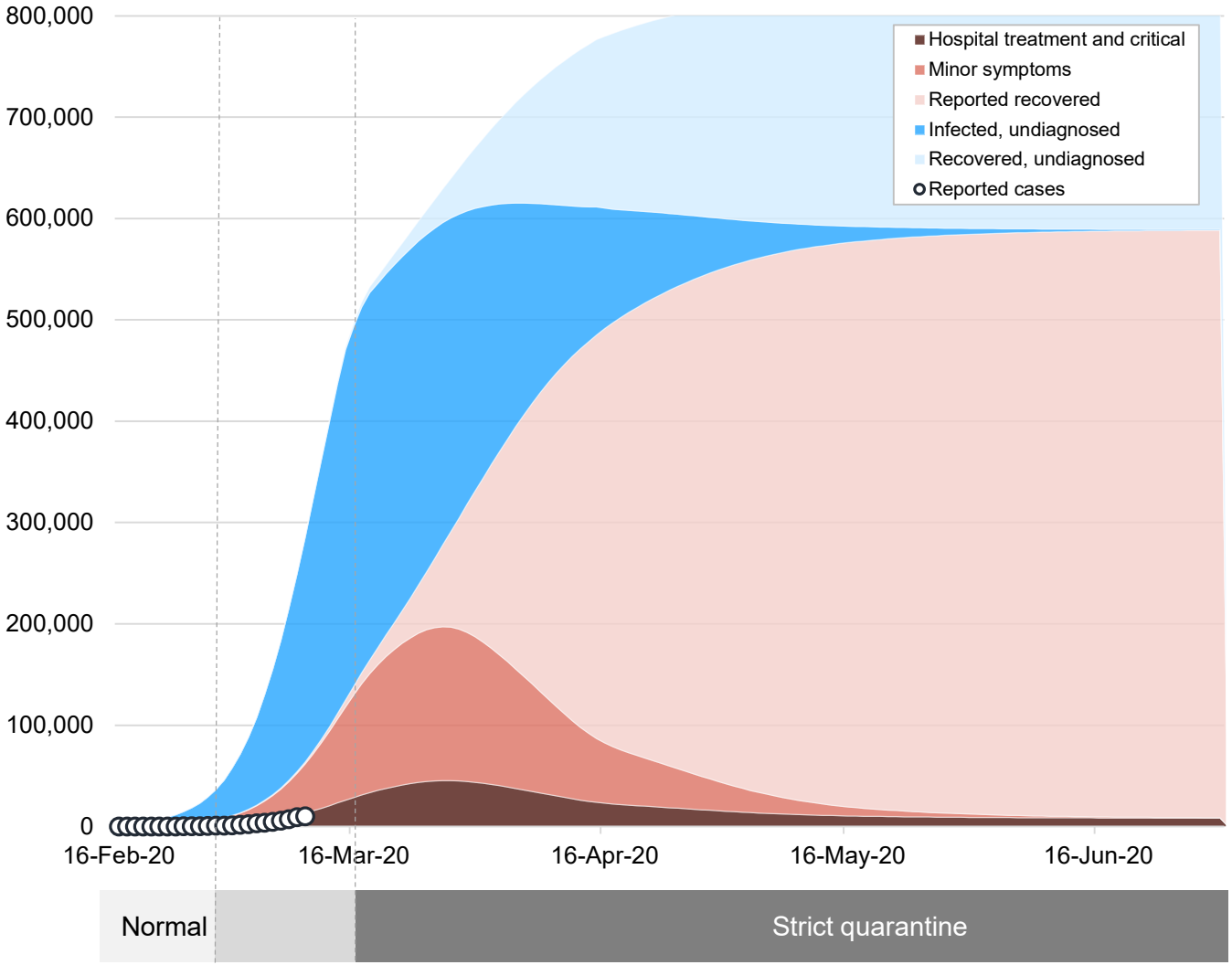
If the quarantine measures are effective at reducing interactions to one contact point per person per day, and last until 1 June, then 29 March may be the point of peak infection with approximately 200,000 actively ill, out of which 45,000 will require hospitalization.

Source: Rystad Energy research and analysis; Reported cases from Worldometer.

Effective prevention could halt the spread of the outbreak by June

Reported and potential total COVID-19 cases by disposition
Number of individual cases

Time period:
February 16 – July 1



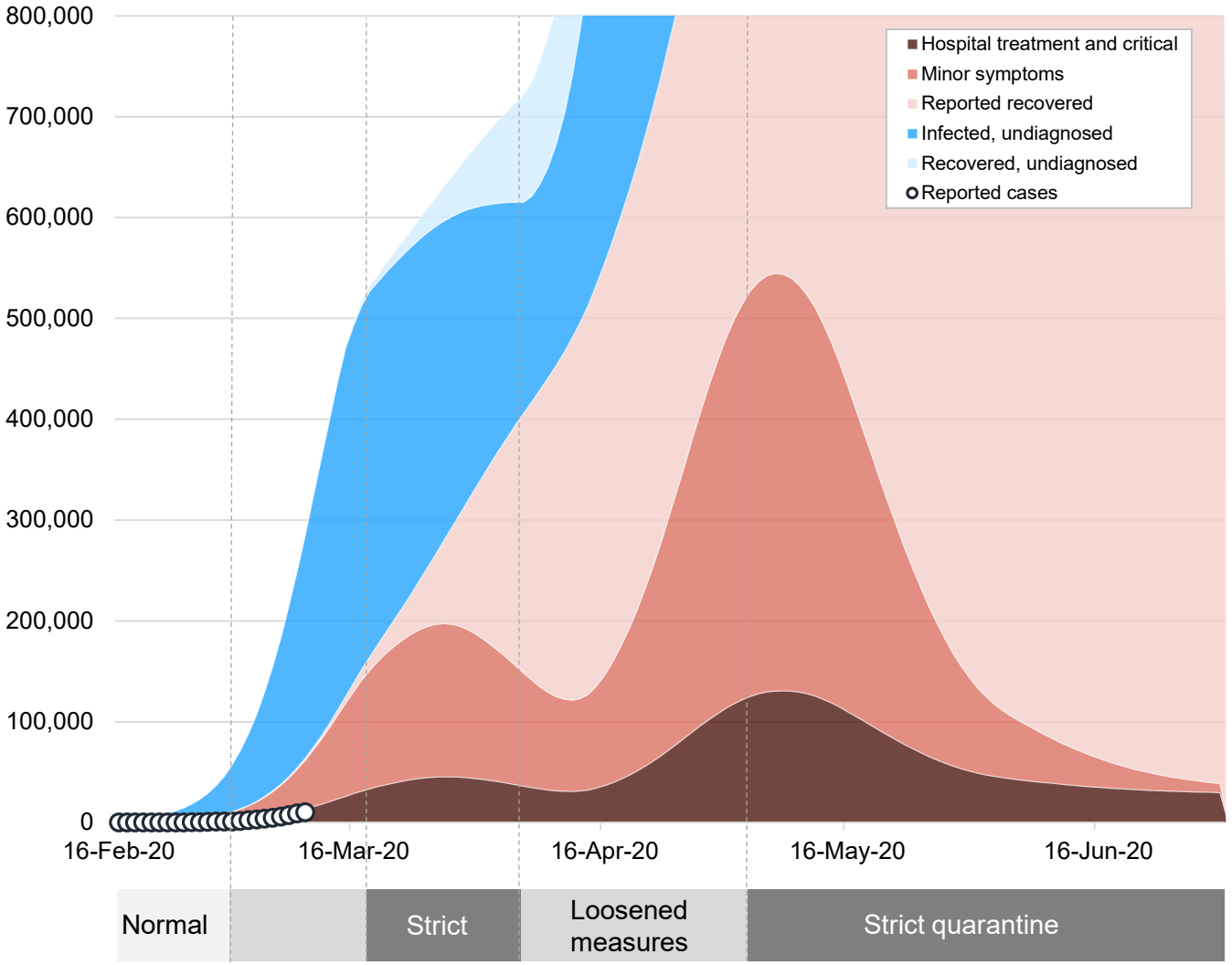
Effective quarantine measures could end the spread of the outbreak by June, with the total number of infected people at approximately 830,000, of which 240,000 will be fully recovered and asymptomatic.

Source: Rystad Energy research and analysis; Reported cases from Worldometer.

Less effective prevention could result in a secondary outbreak affecting 2.8 million

Reported and potential total COVID-19 cases by disposition
Number of individual cases

Time period:
February 16 – July 1



- Our Less Effective Prevention Scenario simulations for Italy make the same assumptions as in the Effective Scenario until 5 April.
- In our Less Effective Scenario, quarantine measures are loosened after 5 April, resulting in the number of interactions per person per day rising steadily back to 10 people per day by 15 April.
- At this point, we anticipate strict quarantine measures will again be implemented, reducing the rate of contact down to one by 1 May. This new quarantine will persist until August in order to halt the spread of the virus.
- The number of infected people, including those recovered, will have then grown to 2.8 million by 1 July, a number not visible on the plotted axis on this page.
- A second infection peak will appear 8 May, with 545,000 total people infected, of which 130,000 will require hospital treatment.

Source: Rystad Energy research and analysis; Reported cases from Worldometer.

Content

Executive Summary

Outbreak scenarios and effect of preventive measures

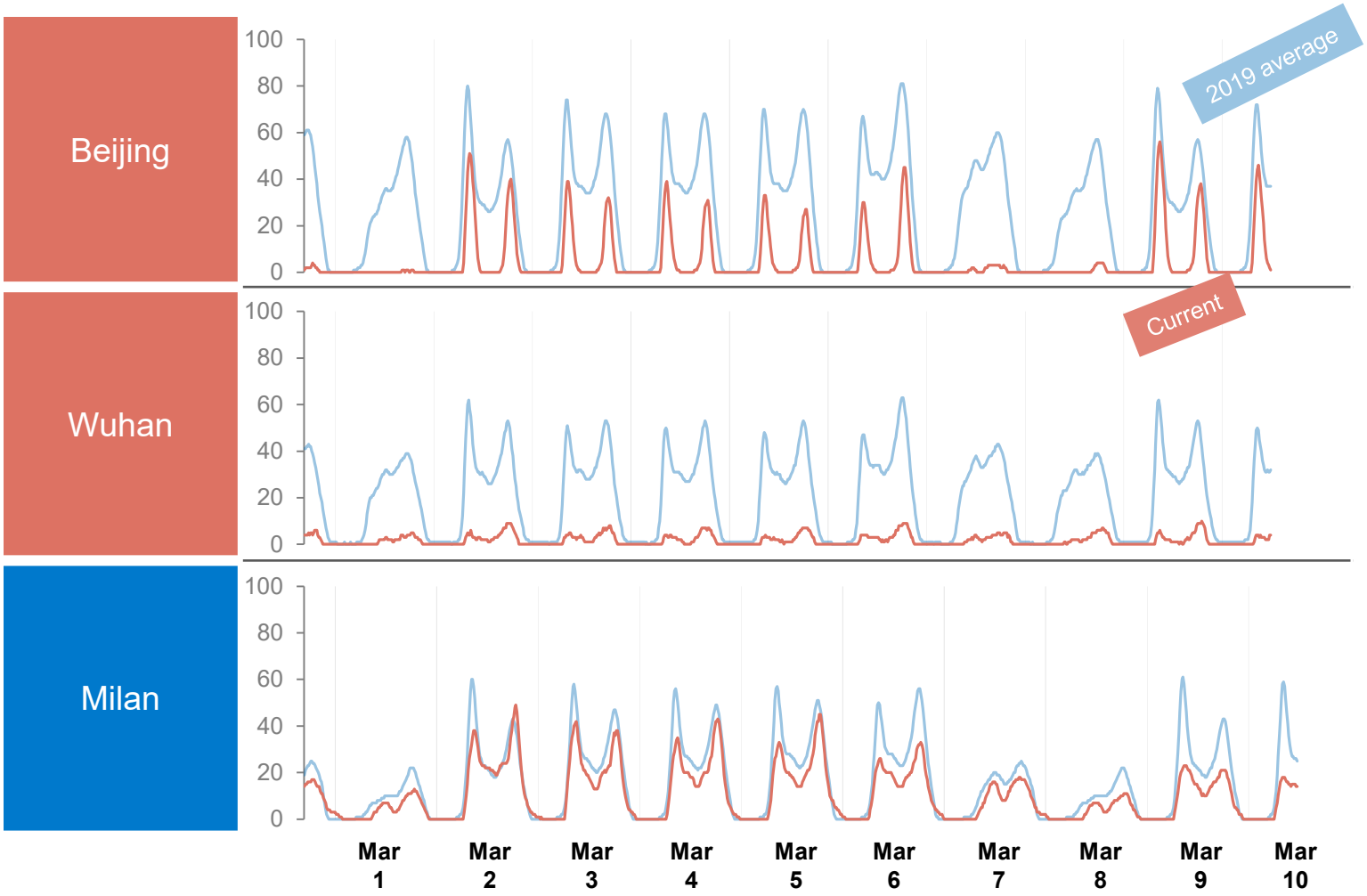
Outlook for the impact on the energy sector

- Ground transportation
- Aviation
- Global impact

Methodology

Traffic congestion is significantly down in areas impacted by COVID-19

Daily road traffic congestion in Chinese cities, Index

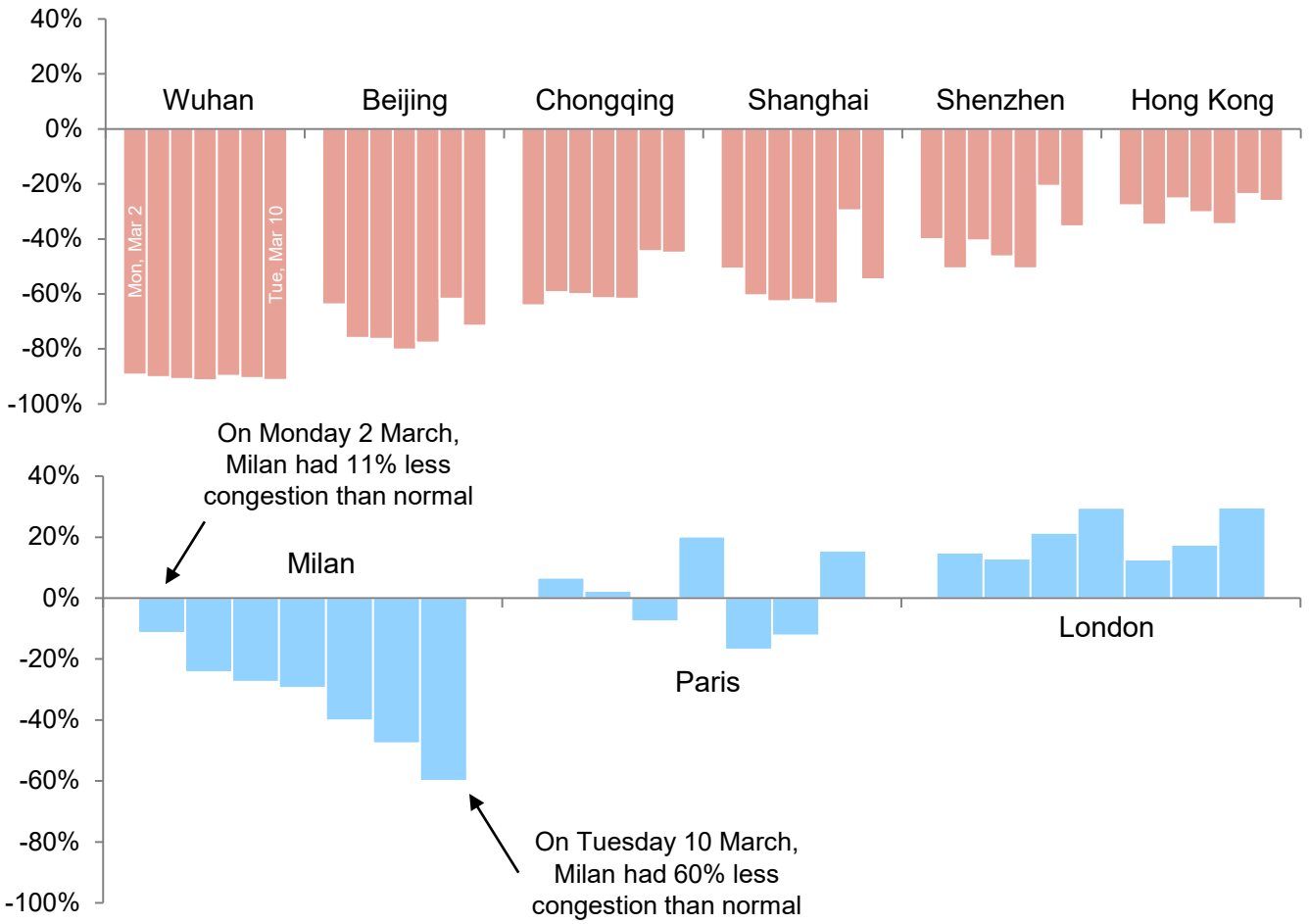


- China has been successful in reducing the number of contact points between people, and is currently loosening quarantine measures at a handful of locations.
- As quarantine measures are loosened and employees return to work, rush hour traffic is returning to 50% to 60% of normal levels.
- Outside rush hours, and during weekends, traffic levels remain more than 80% lower than normal levels.
- In Milan, we have seen sharper drops in congestion in the past few days, as stricter quarantine measures have been implemented.

Source: TomTom Traffic Index, Rystad Energy research and analysis

Traffic congestion in China down 50% to 60%, congestion in Milan rapidly decreasing

Change in congestion levels versus normal levels
Percent difference from 2019 average levels

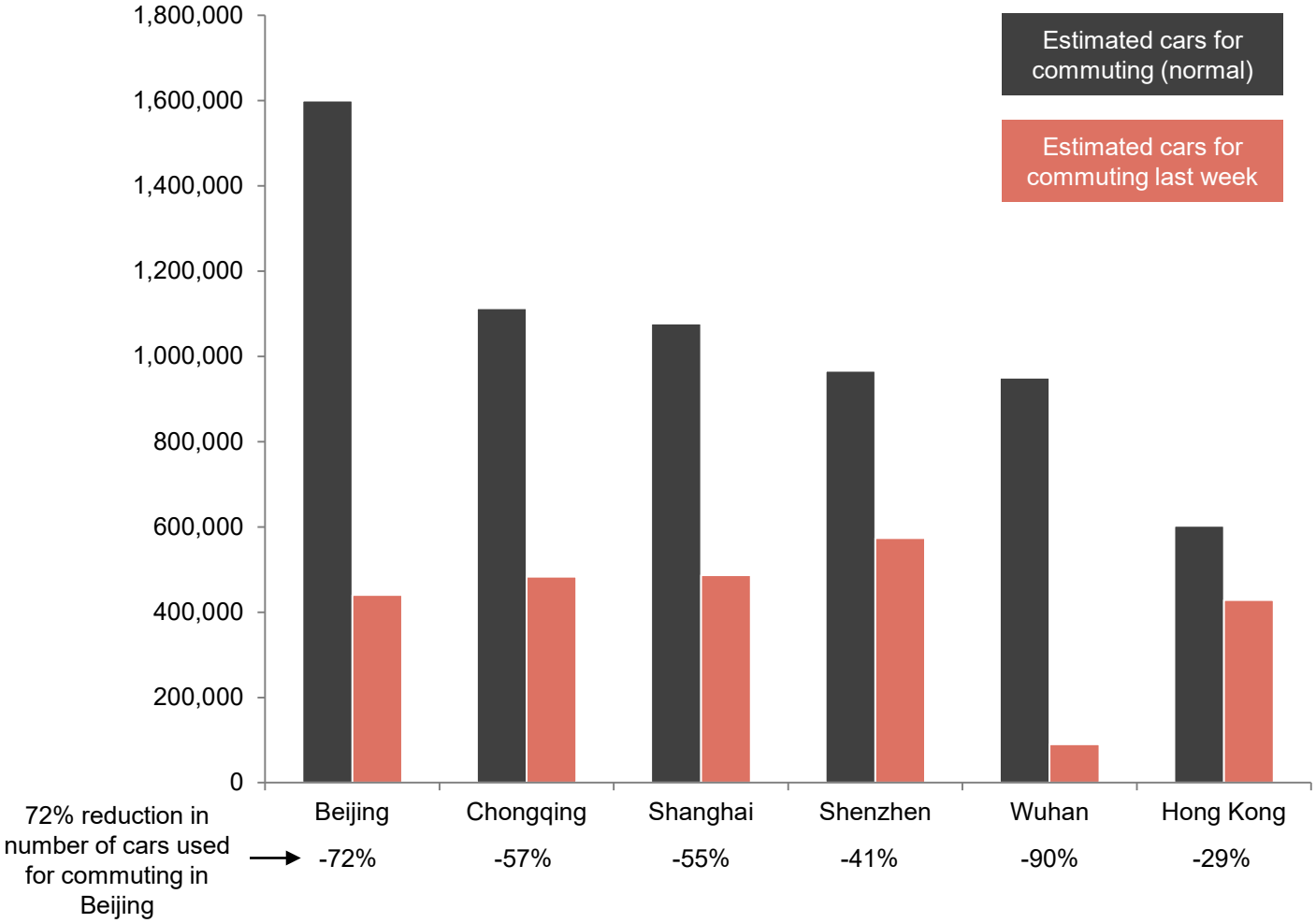


- Congestion levels are correlated with the number of vehicles on the road.
- In China, congestion is visibly down compared to the average levels seen over 2019.
- This effect is stronger in the south, where higher temperatures have decreased the spread of the virus.
- By comparing the reduction in traffic congestion during rush hours, we observe that quarantine measures in China have reduced road traffic by up to 80%.
- In the last week road traffic in Milan has trended downwards towards the levels seen in China.
- With quarantine measures in China loosened for employees returning to work, rush hour traffic is returning to 50% to 60% of normal levels.
- Outside rush hours, and during weekends, traffic levels remain more than 80% lower than normal levels.

Source: TomTom Traffic Index, Rystad Energy research and analysis

The number of commuting cars in China was around 50% of normal levels last week

Number of cars for commuting before and after February/March
Count

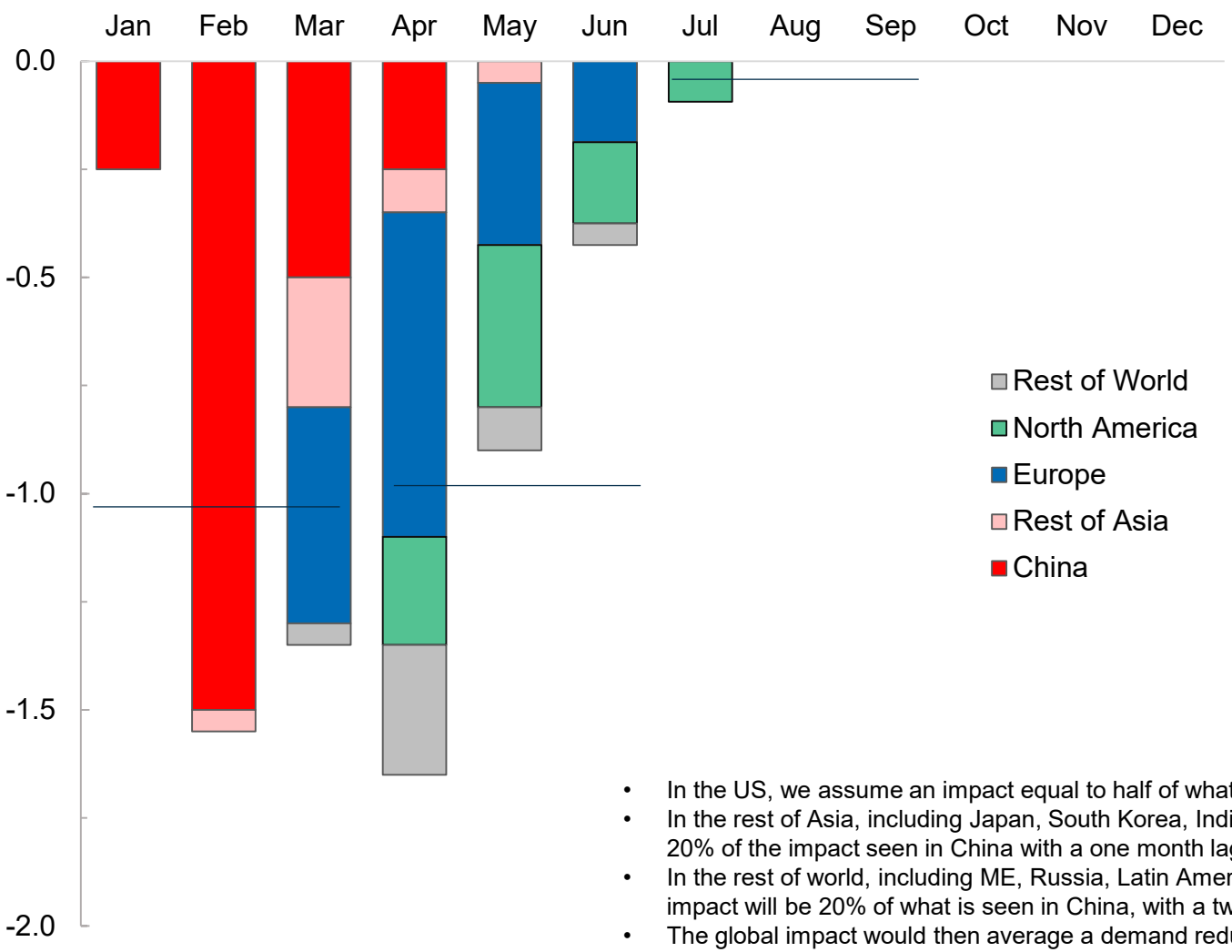


- We have estimated the number of passenger cars used for commuting in six major cities in China; we observe that Beijing has 1.6 million cars, Chongqing, Shanghai, Shenzhen and Wuhan each have around 1 million cars and Hong Kong has around 600,000 cars.
- We estimate the reduction in the number of passenger cars on the road in Wuhan is as high as 90% due to the strict quarantine measures imposed by the government.
- We see a trend of 40% to 60% reduction for cities like Chongqing, Shanghai and Shenzhen. These cities are considered to have a sub-tropical climate, which reduces the transmission rate and thus limits the impact on the number of commuters by car.
- The cold continental climate in Beijing increases the transmissibility of COVID-19 which is reflected our estimate, which exhibits a 72% reduction in passengers vehicles in Beijing.
- On the other hand, we estimate an impact of just 30% in Hong Kong. The government of Hong Kong imposed a quarantine for people arriving from mainland China in early February, which we believe effectively reduced the spread of COVID-19.

Source: TomTom Traffic Index, Rystad Energy research and analysis

Gasoline and diesel road fuel demand was likely down 1.5 million bpd in China in February

COVID-19 impact on 2020 gasoline demand by region*
Million barrels per day



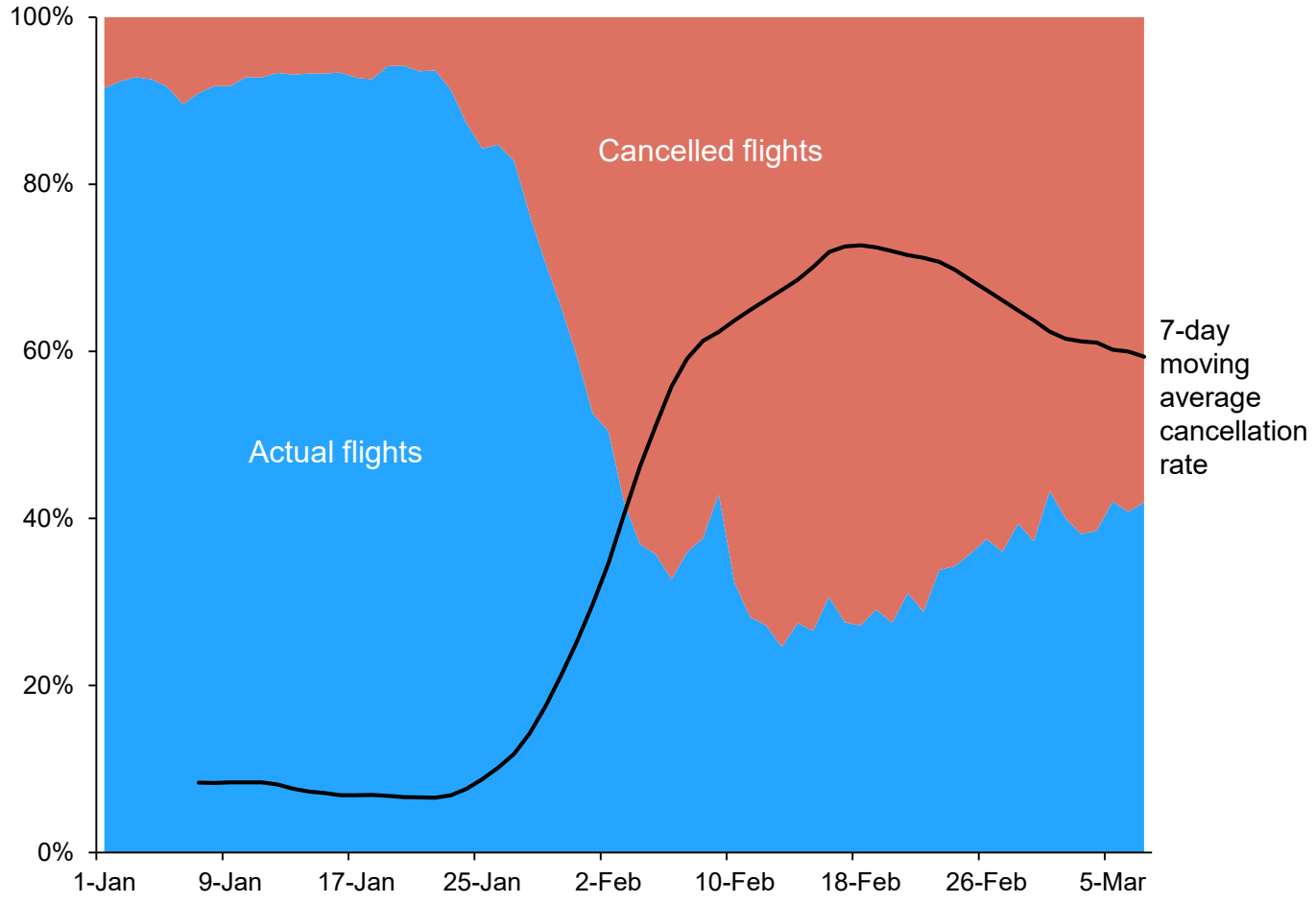
- In China, commuting road traffic was down 50% in February. By early March, we see that traffic is gradually returning to normal levels outside of the Hubei province.
- Normal pre-virus road fuel consumption in China stands at 5 million bpd, 3 million bpd of which is at risk given the decreases in personal transport and commuting.
- The impact has lasted for three months so far. We estimate the peak monthly impact will be a 1.5 million bpd decrease in gasoline demand in February vs pre-virus estimates.
- In Europe, we may expect an increased number of cities to implement quarantines and travel restrictions, in addition to those already in place in Italy. From this, we assume peak impact will be half of what we saw in China in terms of volume of reduced demand. However it remains to be seen if quarantines in Europe will be longer than those seen in China.

- In the US, we assume an impact equal to half of what we will see in Europe, with a one month lag.
- In the rest of Asia, including Japan, South Korea, India, and SEA, we assume the impact will be 20% of the impact seen in China with a one month lag
- In the rest of world, including ME, Russia, Latin America, Africa, and Australia, we assume the impact will be 20% of what is seen in China, with a two month lag.
- The global impact would then average a demand reduction of 1 million bpd for 1Q and for 2Q, and an average demand reduction of 500,000 bpd for the whole year.

* Reduction versus pre-virus estimates
Source: Rystad Energy research and analysis

In February over 50% of all planned flights in China were cancelled

Cancelled and actual flights as a percentage of planned flights for China in 2020
Percent

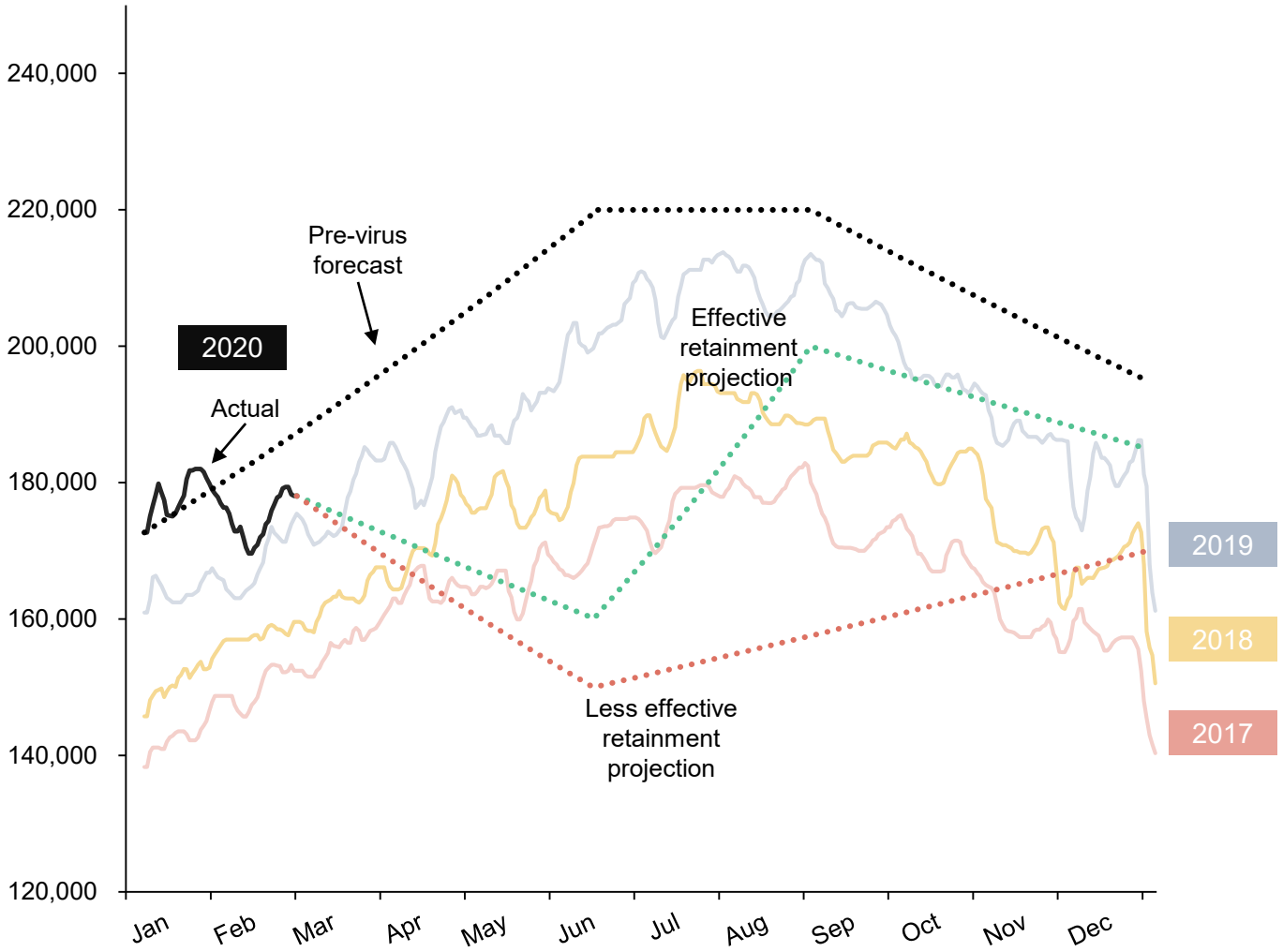


- In January, between 5% and 10% of all planned flights in China were cancelled.
- After protective quarantine measures were taken, this cancellation rate jumped to around 60%, with a peak of over 70%.
- In the past week, activity has begun to pick up, with the cancellation rate falling to 50% to 60%, primarily thanks to increased activity from Chinese airlines.
- International airlines are still cancelling most flights to China, with airlines such as Lufthansa and United Airlines suspending flights to China until the end of April.

Sources: ICAO, CARNOC, Rystad Energy research and analysis

Global flight traffic could fall 15% from expected pre-virus levels in 2020

Number of flights tracked by Flightradar24, 7-day moving average



- **Lufthansa**
  Canceled over 25% of short- and medium-haul flights. Overall, more than 7,100 flights have been cancelled in the coming months.
- **Air France**
  The number of passengers on Asian flights is down 24.5% in February. European services cut by 25%.
- **United Airlines**
  Cut international schedules by 20% and domestic schedules by 10%.
- **Ryanair**
  Reduced flight program by around 25% in March and April.
- **Cathay Pacific**
  Capacity cut by 40% and over 60% of scheduled flights have been cancelled.
- **Singapore Airlines**
  Suspended over 3,000 flights from February to May for more than 70 destinations.
- **Norwegian Air**
  Will cancel 3,000 flights over next 3 months, ie 15% of their flights.

*Forecast is based on previous years growth patterns.
Sources: Flightradar24 (https://www.flightradar24.com/blog/commercial-air-traffic-down-4-3-in-february-2020/), company reporting, Rystad Energy research and analysis

The impact on global air traffic could be 50,000 to 60,000 fewer daily flights in June

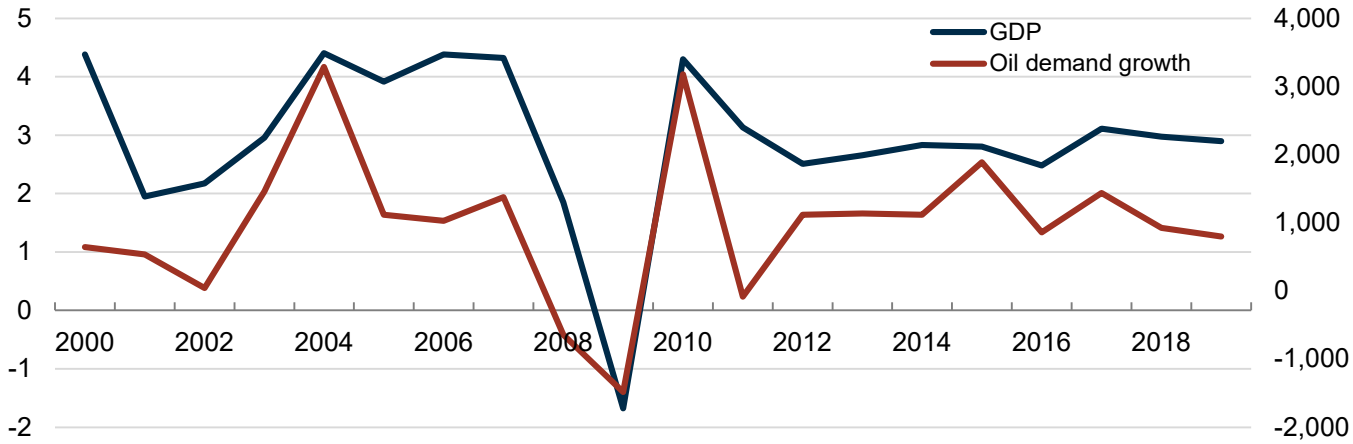
Reductions in daily number of flights compared to pre-virus base-case forecast

- Airlines will see less demand for travel as COVID-19 spreads to larger parts of the population, first in Europe and Middle East, then in North America.
- In addition, many distressed airlines will also have to cut costs by cutting non-profitable routes.
- As a base case, we assume the common summer air travel peak will occur later in the season, so the global daily flight count would be 7,000/44,000/31,000/13,000 lower than the pre-virus forecast in 1Q/2Q/3Q/4Q.
- Pre-virus predictions indicated about 200,000 daily flights over the year, with about 7 million bpd expected jet fuel consumption for 2020, or 35 barrels per average flight.
- We therefore expect impact will be 250,000 bpd less jet fuel consumption in 1Q, 1.5 million bpd less in 2Q, 1.1 million bpd less in 3Q, and 500,000 bpd less in 4Q.
- In a worst case scenario, with air traffic falling further to 150,000 flights per day in 3Q and onwards, we could see 600,000 bpd less jet fuel consumption in 1Q, 1.8 million bpd less in 2Q, 2.2 million bpd less in 3Q, and 1.3 million bpd less in 4Q.

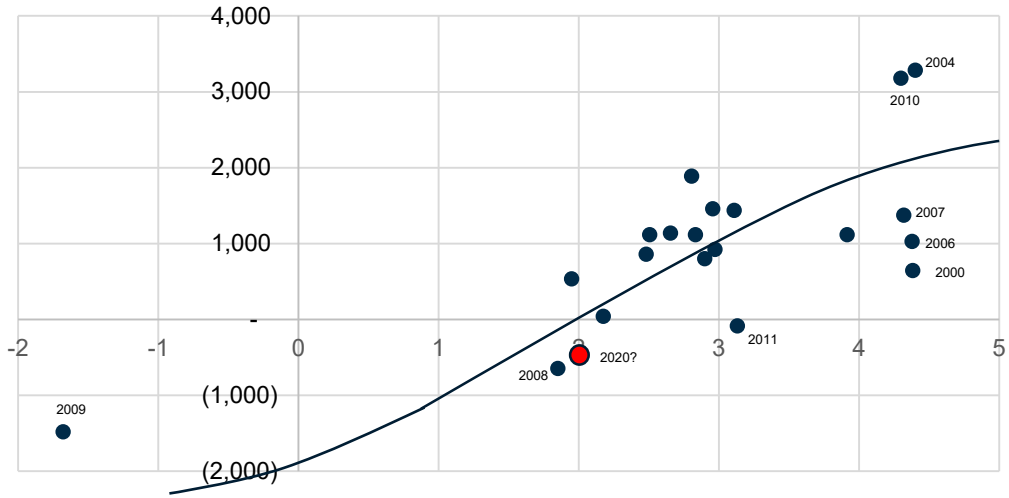
Sources: Flightradar24, Rystad Energy research and analysis

Global GDP growth slowing to 2% would result in an additional -500,000 bpd of oil demand

GDP growth (percent, LHS) versus oil demand growth (kbbld, RHS) per year



GDP growth (x-axis, percent) versus oil demand growth (y-axis, kbbld) per year 2000-2019

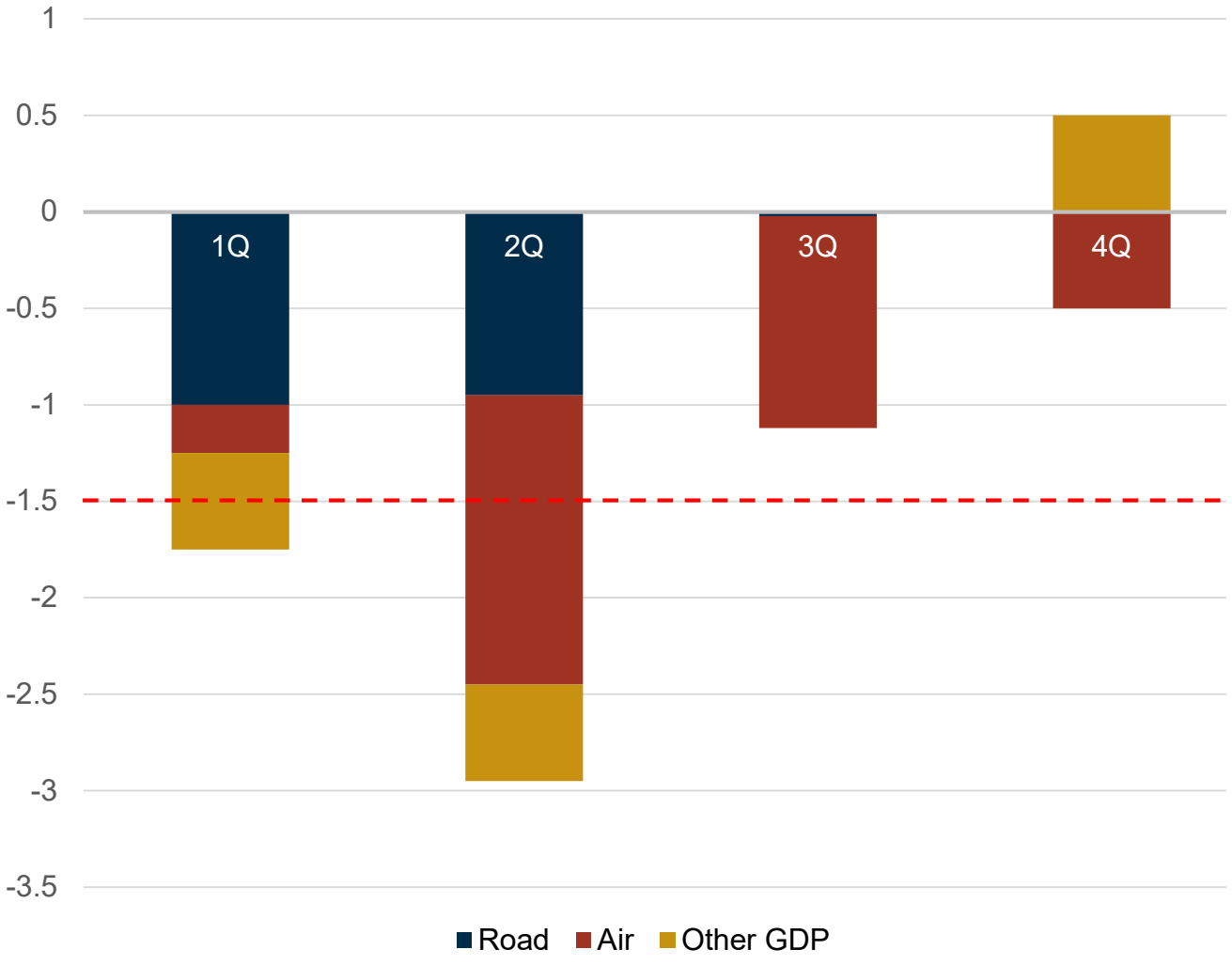


Source: Rystad Energy research and analysis

- Global oil demand growth is strongly related to GDP growth. The relationship is given by oil demand intensity, which gradually decreases with improved fuel efficiency and – going forward – electric vehicle market penetration. The correlation is not fully linear due to demand elasticities.
- Our research indicates that pre-virus global oil demand in 2020 would be flat if GDP growth was to slow down to 2% (IMF: “global recession”), while oil demand growth would be 1 million barrels per year if global GDP was to expand by 3%.
- However, based on the latest reporting on the spread of COVID-19 and the state of the stock markets, many analysts see global GDP growth slowing further to 2% for the year 2020.
- Based on this we estimate the GDP impact on oil demand will be a growth reduction of 500,000 bpd. In other words, this includes all demand drivers other than road and air traffic.

Total impact on global oil demand is projected at -3 million bpd for the second quarter

2020 coronavirus impact on global oil demand*
Million barrels per day



* Difference versus pre-virus estimates
Source: Rystad Energy research and analysis

As COVID-19 continues to spread, the aggregated impact of currently or previously implemented quarantines has resulted in an observed reduction of both road traffic and airline traffic. As illustrated, we expect oil demand reduction due to diminished airline traffic will have the biggest impact in 2Q. The impact of sustained reduced road traffic should also be expected to persist at the same level as seen in 1Q, when Chinese and South Korean cities were nearly shuttered completely, and traffic in Europe slowed.

Our pre-virus estimate for global oil demand y/y growth in 2020 (as of January 2020) was the addition of 1 million bpd.

In their report earlier this week, the IEA estimated oil demand would be flat or marginally down this year.

Rystad Energy estimated last week that oil demand growth would see the addition of 500,000 bpd y/y in 2020. This was before Italy went into full quarantine mode, and airlines saw massive cancellations for 2Q.

Based on our latest simulation on the spread of the COVID-19, we are now revising our demand projections down further.

We now expect global oil demand to fall by 500,000 bpd in 2020 vs 2019

RYSTAD ENERGY WEBINAR: CORONAVIRUS IMPACT ON THE ENERGY SECTOR

We welcome you to join our upcoming webinar where Jarand Rystad, CEO, and Per Magnus Nysveen, Head of Analysis, will discuss the impacts of the coronavirus on the energy sector. The session will be moderated by Matthew Watson, Director Global Sales.

DATE: March 18, 2020

TIME: Session 1: 9:00 am (Oslo time)/4:00 pm (Singapore time)
Session 2: 4:30 pm (Oslo time)/10:30 am (Houston time)

Jarand Rystad , CEO

Register for the Session

Per Magnus Nysveen, Head of Analysis

Content

Executive Summary

Outbreak scenarios and effect of preventive measures

Current trends of the outbreak, preventive measures and impact

Outlook for the impact on the energy sector

Methodology

Methodology

Our simulation models the number of new people being infected every day based on the following parameters:

- Contact rate per person per day:
  - How many people one person meets every day. Assuming one person is infected, but unaware, this is the situation where the virus could be transmitted.
  - Typically one person interacts with 10 persons in one day. In an effective quarantine, this is reduced to 1 (not 0, as some people will not comply)
  - In our simulations we can manipulate this number day by day based on personal awareness or compliance and government initiated restrictions/quarantines
- Transmissibility:
  - When meeting another person, what is the likelihood of transmitting the virus? Our base assumption is 4% in the winter and 2% in the summer. This number is higher in the winter, since droplets from the breath or coughing are smaller and spread more easily in cold, dry air.
  - People who are known to be infected will exhibit much lower transmissibility, as health personnel and family will take precautions to avoid being infected. In this case, we assume 1 contact per day, and 0.5% transmissibility. I.e. for one person sick for 15 days, the likelihood of contaminating someone else is 7.5%.
- Incubation time and recovery time:
  - This is the time from exposure to the development of symptoms. We expect this to be 5.2 days, with 4 days of standard deviation, following a lognormal distribution, ranging then from 1 day to 14 days for 85% of the cases. We assume that all surviving people will recover within 35 days after initial contamination. With this, the reproduction number (R_0) becomes 10*4%*5.2 = 2.1
  - We assume that 20% of cases will exhibit symptoms severe enough to require hospitalization, of which 5% will get very sick and need intensive care. The fatality rate is assumed to be 1% based on cases in South Korea and China outside Hubei, which have had extensive testing. (We assume that reported figures elsewhere of up to 3.4% fatality rate are due to the underreporting of actual infected cases in that region.)
  - While the fatality rate is an important metric for the initial calibration of the model on a geographical basis, it is not critical for our forecasting of quarantine measures. Therefore, we do not forecast fatalities in the model. Fatalities and critical cases are grouped together with lighter hospital cases within the “hospital treatment and critical” group.
- Testing and registration of sick cases:
  - Some people will remain asymptomatic and recover without ever being aware of having been sick
  - An input to the model is the number of people that will recover without ever being tested or registered as infected. This number can change from day to day as the testing capacity and awareness in a society can changes as the virus develops

Methodology

The simulation is accomplished first by calibrating the actual number of reported cases, fatalities and recovered cases through experimenting with contact rates, transmissibility, import of infected cases and transparency (testing and registration) up to the current date. Input to the model every new day is the total number of infected cases (unaware and aware) that day. This will create a new group of infected people for this particular day that will follow a certain distribution in terms of incubation time and transparency. The sum of all of these previous groups gives the new number of infected people the next day, etc.

From the current actual day, we then make simulations using contact rate (how strict and quick quarantine measures are) and transmissibility (lower with warmer weather). In general we have been aiming for three scenarios:

Effective Prevention Scenario: A strict quarantine is implemented, bringing contact rates gradually down to 1 (usually in less than 9 days), where it remains until the final case has recovered.

Less Effective Prevention Scenario: Strict quarantine measures are take as in the previous case, however quarantines are loosened after about one month, and then brought back when the negative effect becomes apparent.

Note, we do not simulate any “worst case” scenarios wherein societies essentially do nothing and let the infection spread unhindered. The result of this would be that 80% of the population in any urban region would be infected within 8 weeks of reaching 1000 cases.

RYSTAD ENERGY

Rystad Energy is an independent energy consulting services and business intelligence data firm offering global databases, strategy advisory and research products for energy companies and suppliers, investors, investment banks, organizations, and governments. Rystad Energy's headquarters are located in Oslo, Norway.

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