Green Stimulus and Recovery Series

ACHIEVING A GREEN RECOVERY FOR CHINA:

Putting Zero-Carbon Electrification at the Core

ENERGY TRANSITIONS COMMISSION

ROCKY MOUNTAIN INSTITUTE

The COVID-19 crisis has had a massive impact on economies across the world, with several governments now seeking to design recovery programmes. Ideally such programmes should not only support recovery from recession but help achieve greener and more sustainable economies for the future.

Rocky Mountain Institute (RMI) has therefore released a ***Global Stimulus Principles*** paper, which sets out principles to guide stimulus programmes across the world. The Energy Transitions Commission (ETC) has also published a paper setting out **seven priorities to help the global economy recover**. However, detailed implementation of those principles and priorities must reflect specific national conditions. This joint RMI/ETC report therefore proposes a programme for sustainable recovery in China which reflects the specific characteristics of the Chinese economy and policies already in place. It is written by a combined team of Adair Turner, chair of the global Energy Transitions Commission, together with Ji Chen and Jiayin Song from RMI.

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EXECUTIVE SUMMARY

China has come through the COVID-19 pandemic with far fewer infections and deaths per capita than major Western countries. Its factories and distribution systems have returned to normal operations faster than expected. But with exports to Europe and the United States now likely to be severely depressed by recessions in those regions, China faces a year of slow growth and will need to stimulate domestic demand to spur economic recovery and job creation.

That stimulus should aim as best possible to encourage domestic consumption, which remains structurally low as a percentage of GDP. But social distancing and other health-related constraints are likely to slow the recovery of the hospitality, leisure and domestic tourism sectors, and Chinese consumers may be cautious about spending in the aftermath of the COVID-19 shock. Investment stimulus must therefore play a significant role in economic recovery programmes, as it did after the 2008 global financial crisis. If well-designed it could not only stimulate the economy but help build a higher value-added and more environmentally sustainable Chinese economy, avoiding the downsides of the stimulus programme launched after 2008.

China's government has recognised that this time the investment stimulus should be different. Premier Li Keqiang's government report presented on May 22nd already sets out three key elements of a green stimulus that can support China's emerging new economy,[1] with commitments to:

- **Strengthen investment in "new" technology-based forms of infrastructure**, such as 5G, artificial intelligence, internet of things, data centres, and optical fibre, which will build Chinese capacity in a range of vital future technologies
- **Ensure that investment in traditional infrastructure supports green and energy efficient urbanisation**
- **Promote green consumption, including via support for electric vehicles**

A fourth pillar of this programme should now be added with clear policies to:

- **Accelerate investment in zero-carbon electrification.** This should combine increased investment in wind and solar capacity, ultra-high voltage transmission lines, energy storage, and distribution grids, plus the accelerated rollout of electric vehicle charging infrastructure

This report describes why this should be a priority, alongside the other three policy thrusts. It describes why zero-carbon electrification is technically and economically feasible and should be a key focus in the 14th five-year plan. It sets out appropriate objectives within the first three programme elements and policies that could help achieve them. And it shows how the four programme elements together would assist recovery from the COVID-19 crisis and build a green high-value Chinese economy for the future.

It describes in turn

I. The current economic background and the need for a different form of investment stimulus than was deployed after the 2008 global financial crisis

II. The role which different forms of investment can play in both driving post-crisis recovery, and in building a more sustainable, high-value Chinese economy

III. The four pillars of an optimal investment programme: aspects, benefits, and policy instruments

ECONOMIC BACKGROUND: SIMILARITIES AND DIFFERENCES FROM 2008

China's GDP in Q1 2020 was down 6.8 percent from a year earlier, as the nation deployed extensive lockdowns to beat the COVID-19 crisis. Starting in March and April, economic activity has recovered, and is now roughly comparable with the equivalent period in 2019.[2] April export performance was also reasonably strong. But with Europe and the United States in deep recessions and only now beginning to come out of lockdowns, China still faces big headwinds to growth and the future economic path is very uncertain. Reflecting this uncertainty, the government has decided not to set a specific growth target for 2020.

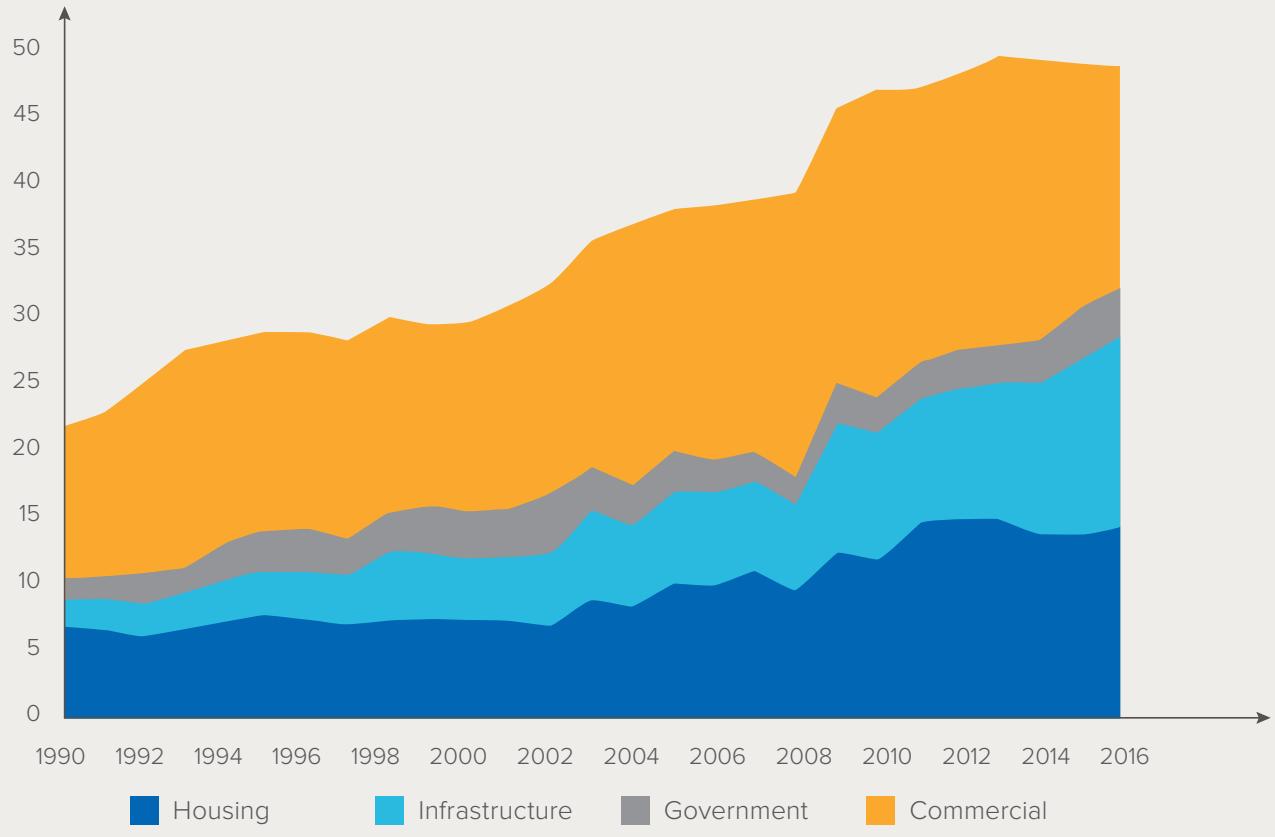
In this environment, government policy must stimulate domestic demand. The work programme announced on May 22 set out three forms of stimulus finance: (1) an increase in the fiscal deficit from 2.8 to 3.6 percent, with an additional RMB 1 trillion (1 percent of GDP) of special government bond issue to support COVID-19 control (2) authority for local governments to issue RMB 3.75 trillion of special-purpose bonds to support investment projects (up from RMB 1.6 trillion in 2019) (3) monetary policy and bank regulatory measures which will enable credit provision to grow at a notably higher rate than 2019's +11 percent.

One objective of policy should be to stimulate domestic consumption, which at 59 percent of GDP is still structurally low. The work programme contains several measures designed to support consumer spending, such as reduced VAT on public transport, restaurants and hotels, and tourism and entertainment. But continued social distancing and other health-related constraints will inevitably slow the pace of recovery of key service sectors. And in the aftermath of the COVID-19 crisis many Chinese consumers will seek to save more, either to rebuild savings after income losses during the crisis or as a precautionary measure in response to heightened awareness of risk.

It is therefore essential also to stimulate the economy via increased investment. If well-designed and targeted, this can not only help drive economic recovery and job creation, but build China's productive capacity and support future prosperity and growth.

In late 2008 and early 2009, in the aftermath of the global financial crisis, China faced global economic headwinds somewhat similar to those it faces today. In response it unleashed an enormous infrastructure and real estate construction boom, financed by rapid expansion of bank lending and large-scale bond issuance by local governments and related financing platforms. Total national investment, which already in 2008 stood at a very high 43 percent of GDP, increased to a peak of 48 percent.[3] This was a level never seen before in a large economy, with housing and infrastructure investment accounting for a greatly increased share of the total. By 2016, investment in these two categories amounted to around 26 percent of GDP, far outpacing business investment in buildings, plant and machinery which amounted to 15 percent. (Exhibit 1)[4]

Exhibit 1: Sector-based Investment's Share in Total GDP (%)



Source: Herd (2017)[5]

This stimulus kept China's growth going at 9.2 percent despite recessions in advanced economies, and supported the continued expansion of urban jobs (+12 million in 2009) at a pace fast enough to avoid significant unemployment.[6] But the particular form of the investment stimulus produced three adverse side effects.

- **Significant wasted investment**, in particular in real estate and some categories of urban infrastructure. Despite President Xi Jinping's admonition that "real estate should be for living in not for speculation", a recent survey done by the People's Bank of China shows that 42% of Chinese urban households own two or more apartments, implying that the vacancy rate now exceeds past estimates of 15–20%.[7] In many cases they will never be occupied. Many third- and fourth-tier cities have built urban infrastructure in excess of likely future requirements. Excessive production capacity also emerged in the steel and cement sectors. And at the macro level, China's capital-output ratio—a measure of how much new capital investment is needed to create useful economic output—increased.[8]

- **A major and potentially dangerous increase in leverage,** in both the banking and shadow banking sectors, with the total debt of the non-financial sector rising from 150 percent of GDP in 2008 to 250 percent by 2017.[9] This growth created financial stability and macroeconomic risks, which have only been contained by many years of disciplined action by the PBOC and CBRC.

- **A large increase in carbon emissions,** with China's total energy-related CO_2 emissions rising from 7.4GT in 2008 to 9.2 GT by 2017.[i 10] This was the inevitable consequence of the construction boom, given the high carbon intensity of steel and cement production.

In designing an investment stimulus programme to respond to the COVID-19 crisis, China should seek to avoid these dangers. It should also anticipate and respond to three changes in the demographic and social context which make a different investment mix appropriate and feasible.

- **A changing urbanisation challenge.** In 2008, China's urban population was 46 percent of the total. In 2019 it passed 60 percent.[11] Significant further urban development will still be required—developed economies typically have urbanisation rates of over 75 percent. But as China begins to approach the end of its urbanisation wave (which will reach completion within about 15 years) the nature of the urbanisation challenge will change. With the total population due to peak in the mid-2020s and decline gradually that after, many cities will see no further population growth and face an increasing danger that excessive investment will create permanent waste.

  Meanwhile China is leading the world in thinking about urban clusters, which can support productivity growth in a changing technological context, and it is essential to design these in a sustainable and energy-efficient fashion. Overall, China's investment in urbanisation must shift from large quantity to high quality.

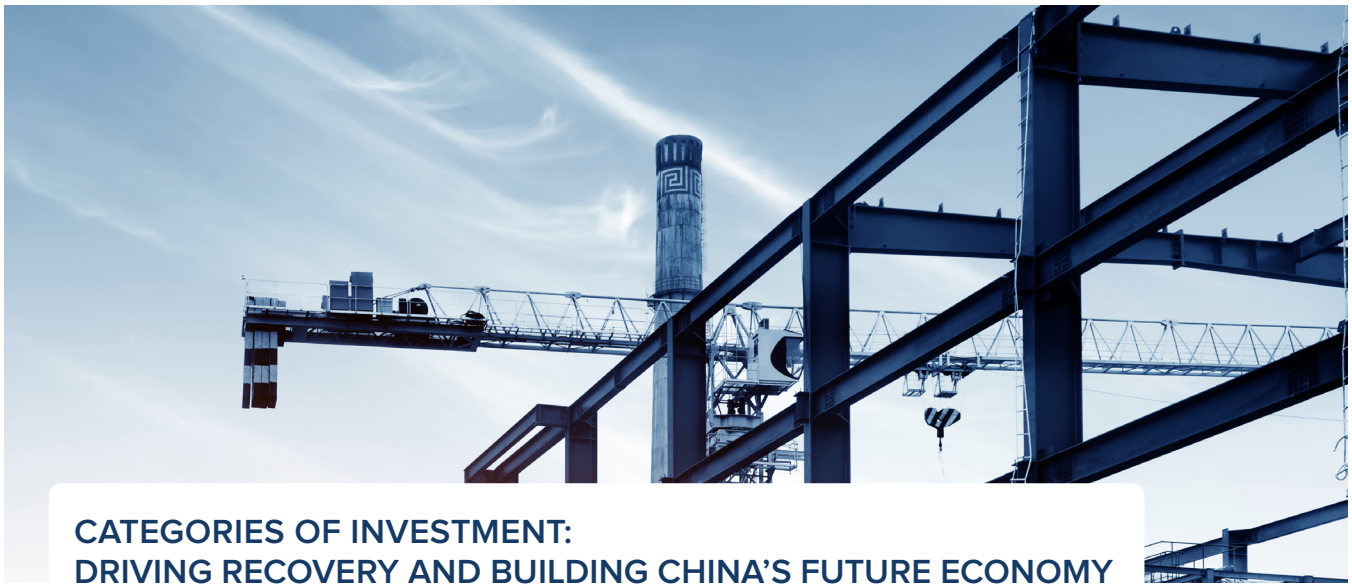
[i] These carbon emissions reflect only those through consumption of oil, gas and coal for combustion-related activites.

- **Reinforced demand for clean skies and water.** The "new type of urbanisation" to which Premier Li referred in the work programme speech should also include a reinforced focus on local environmental quality to create liveable green cities for increasingly prosperous Chinese people. Across the world and in China, lockdowns revealed how clean and attractive urban environments can be when the internal combustion engine is banished and industrial pollution reduced.

  Meanwhile, an increasing body of evidence has illustrated the severe health effects of local air quality. China's overall mortality rates are likely to fall in 2020, with reductions in premature deaths from poor air quality exceeding total COVID-19 fatalities.[12] China's recovery programme should therefore seek to preserve and reinforce the temporary environmental gains which emerged as a by-product of the lockdown.

- **A declining employment creation challenge.** China's working age population will fall by about 20 percent over the next 30 years, and the number of new entrants to the working age (20 to 30-year-olds) will fall by around 11 percent in the next 10 years.[13] Meanwhile, as urbanisation continues but at a gradually declining pace, the net flow of migrant workers from rural to urban locations will gradually slow.

  As a result, while job creation must continue to be a very important focus of short term policy, particularly in the period of immediate recovery from the crisis, over time China's challenge will shift from job creation to how to drive productivity growth fast enough to grow prosperity in the face of gradual labour force decline. The post-crisis investment stimulus should therefore be designed to reflect this medium-term shift. The urban job target for 2020 of 9 million set out in the government work programme is significantly lower than 2019's 13 million; this reflects realism about what can be achieved in the face of post-crisis headwinds. But the appropriate medium-term target will also begin to decline gradually over the 2020s in the face of demographic change.



CATEGORIES OF INVESTMENT: DRIVING RECOVERY AND BUILDING CHINA'S FUTURE ECONOMY

An optimal investment stimulus would both drive growth and employment recovery from the COVID-19 crisis and help build an advanced technology, high productivity, energy-efficient, and low carbon economy. Different categories of investment can contribute more or less to the two different objectives. It is therefore vital to determine the appropriate mix of different categories and to be clear what benefits each can deliver.

There is already a rich debate in Chinese policy circles about the choice between "traditional" versus "new" infrastructure investment.

- By "traditional" investment people typically mean the sort of urban and transport system infrastructure which dominated in the post-2008 stimulus: building roads, water and sewage systems, industrial parks, convention centres and highways to support urban development and inter-urban transport links.

- "New" infrastructure is used to refer to various categories of information and communications technology investments: 5G networks, artificial intelligence, internet of things hardware and software, and the data centres and fibre networks to support a digital economy.

- In addition, ultra-high voltage (UHV) transmission lines and high-speed rail and subway systems are sometimes added to lists of "new infrastructure." While some of these involve the same concrete pouring as highways, they also deliver energy-efficient mass transit or support electrification of the economy.

The more clearly "new" forms of information and communications technology (ICT) intensive infrastructure will be vital building blocks for a future high-value and deeply digitalised Chinese economy and have therefore been recognised as priorities in the government work programme. But it is important to be realistic about the potential for such "new" infrastructure to provide immediate economic stimulus and job creation, since the very fact that ICT delivers rapidly increased capability at an ever reducing cost limits the total scale of investment required in these "new" areas.

Exhibit 2 shows an estimate from the China Centre for Information Industry Development (CCID) of possible expenditures on seven categories of new infrastructure investment over the six years from 2020 to 2025, with "direct investment" in these categories amounting to RMB 9.31 trillion, an average of RMB 1.6 trillion per annum, which is about 1.3 percent of likely GDP over that period.[14]

However, the largest expenditure within the total is RMB 4.5 trillion for intercity rail development. Investment in all of the more clearly "new" high-technology categories amounts to RMB 4.8 trillion, or about RMB 0.8 trillion per annum and about 0.7 percent of GDP[ii]. This compares with investment in urban infrastructure and real estate, which continues to account for over half of China's total investment and amounts to more than 20 percent of GDP. As a result, even doubling expenditures on all these forms of "new" ICT-based infrastructure would amount to an investment stimulus equal to just a 3–4 percent increase in "traditional" infrastructure and real estate investment.

Investment in these new categories of infrastructure would in turn tend to produce some knock-on investment in related sectors (for instance, as companies innovate new ways of applying 5G technology once the basic network is in place) and it is possible that this multiplier effect is more powerful for "new" infrastructure than for traditional. The CCID estimates that an additional RMB 6.8 trillion in related investment would be stimulated over the six-year period. But even allowing for this indirectly stimulated investment, the total amounts are still small compared with traditional infrastructure and real estate.

Given this difference in scale, it is almost inevitable that any attempt to use investment to stimulate the economy will involve a significant focus on urban infrastructure and transport systems. Moreover, the specific way in which investment funding is provided may reinforce a bias towards such "traditional" investments and related real estate. For while funding out the central government budget deficit could be focused on any category of investment, there is a natural tendency for bond- and credit-financed stimulus to be focused on urban infrastructure and real estate, since it is easier to secure loans against such physical assets. The current structure of local government finance, which relies significantly on the sale of land for real estate and other developments, also increases the systemic bias towards expansive urban development.

Exhibit 2: Estimates of Total Investment in "New" Infrastructure Areas by 2025 (trillion RMB)

	Direct Investment	Total Investment
5G	2.5	5
Ultra-high voltage power transmission	0.5	1.2
Intercity rail lines	4.5	5.7
Electrical vehicle charging stations	0.09	0.27
Big data storage centres	1.5	3.5
Artificial intelligence-related infrastructures	0.22	0.4
Industrial internet of things	0.65	1
Total	**9.31**	**16.07**

Source: CCID thinktank, March 2020

[ii] GDP number used here is estimated based on a 5% real growth rate with 2% inflation rate for the upcoming 6 years.

The construction of urban infrastructure is bound therefore to play a significant role in China's economic recovery. But optimal policy should seek both to reduce the systemic biases which overly favour such investment and to ensure that new infrastructure investment is made as energy-efficient, green, and sustainable as possible.

Optimal policy should also include a strong focus on the one key category of infrastructure largely omitted from discussion of the appropriate investment stimulus—i.e. investment in a zero-carbon power system and clean green electrification. A power system built of long-term assets to deliver electricity for use across all sectors and regions is as much a strategic infrastructure asset as a high-speed rail network or a 5G network. However, apart from some focus on UHV lines, the power system is not currently recognised as a crucial infrastructure in debates about appropriate infrastructure investment. Nor is it a key area of focus in the work programme.

But accelerated investment in a low-carbon power system could be both a crucial building block of China's future high-productivity economy and provide a more powerful short-term stimulus than investment in the ICT hardware and software categories normally covered by the term "new" infrastructure:

- As the ETC report *China 2050—A Fully Developed Rich Zero Carbon Economy* has shown, the only route to a zero-carbon Chinese economy is one which involves the massive expansion of electricity consumption and total decarbonisation of electricity supply.[15]

    - By 2050, China should aim to consume over 60 percent of its final energy demand in the form of electricity, versus only 20 percent today, electrifying as much of the economy as possible. Such electrification will deliver major economic efficiency advantages, given the inherent merits of electricity as a flexible and efficient energy source, especially when combined with advanced digital capabilities. In addition a further 10 to 15 percent of energy will likely be consumed in the form of hydrogen primarily sourced from zero-carbon electricity via electrolysis, and used in a wide variety of transport and industrial applications.

    - This implies the need for 15,000 terawatt-hours (TWh) per annum of electricity supply in 2050 (versus 6,700 TWh today) all of which will need to come from zero-carbon sources, whether renewable, nuclear, or hydroelectric. This is technically feasible given China's renewable energy resources and can be achieved at no long-term cost to the Chinese economy since renewable energy is now a cheaper source of power than newly-built coal power and will become increasingly so over time.[16]

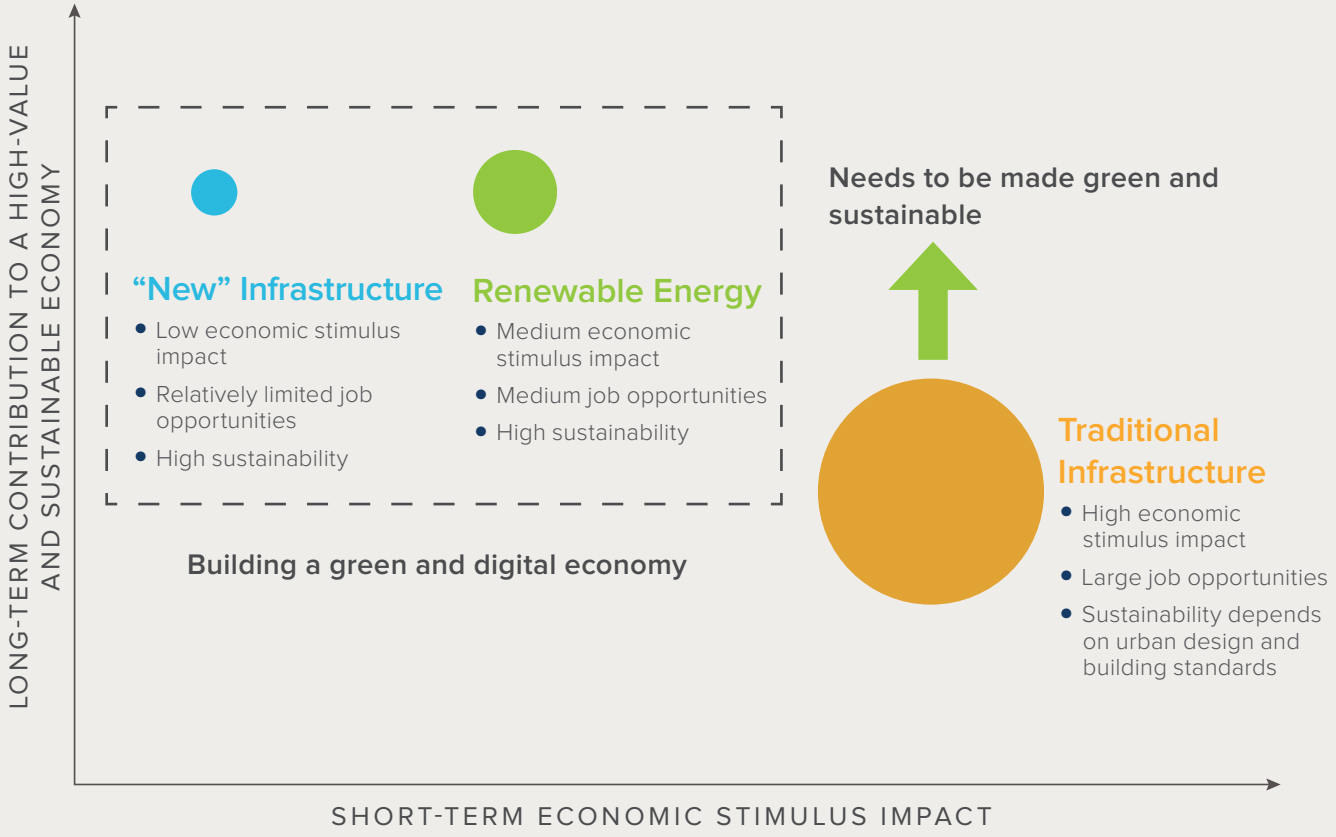
    Building a greatly expanded zero-carbon power system should therefore be seen as a crucial building block in China's strategic economic vision.

- In addition, increased investment in all aspects of a clean power system—renewable energy, nuclear, hydro, new forms of storage, UHV lines, smart grid capabilities and electric charging—could provide an important short-term stimulus to the economy. While the very fact that these technologies are now competitive with coal limits their total cost, the total investment across all these aspects could amount to 1 to 1.5 percent of GDP, making increased investment in clean power a potentially more powerful stimulus than investment in the ICT categories of "new" infrastructure.

Renewable energy and other power system investment should therefore be seen as a crucial element within an investment stimulus programme.

Exhibit 3 sums up the different roles which different categories of investment could play. Traditional infrastructure investment will inevitably dominate in sheer quantity and can create the greatest number of jobs, but must be made as green and sustainable as possible. Renewable energy and related grid investments can have a bigger short-term stimulus impact than new digital infrastructure, but both together need to be seen as linked building blocks of China's future high-value green economy.

Exhibit 3: Comparison of Impact from Different Investments



Bubble size indicates job opportunities created

Source: ETC/RMI

FOUR PILLARS OF ECONOMIC STIMULUS, WITH ZERO-CARBON ELECTRIFICATION AT THE CORE

China's economic recovery programme should be strongly focused on greening the economy, confident that this will deliver both short-term economic growth and job creation and long-term economic and social benefits. Zero-carbon electrification should be at the centre of this strategy, supporting and supported by investment in ICT infrastructure, a green and energy efficient form of urbanisation, and the promotion of green (and increasingly electrified) consumption.

1. Accelerate investment in zero-carbon electrification

Decarbonisation of electricity generation is essential to make the other pillars of the recovery programme green. In 2018, data centres accounted for 161 TWh of electricity consumption (2.35 percent of the total) and China's high-value future economy is bound to consume more electricity.[17] New IT infrastructure in 5G and data centres will generate significant electricity demand. So too will expanded high-speed rail networks, and rail and subway systems to support new forms of urbanisation, and so too will the spread of electric vehicles. It is therefore essential to ensure that growing electricity demand is delivered in a zero-carbon fashion. If electric vehicles use coal-generated power they may cause more CO_2 emissions than diesel or gas vehicles.

China's recovery programme should therefore include both deliberate policies to spur wider electrification of the economy and a commitment that all growth in electricity demand will be met by an expansion of the absolute amount and share of zero-carbon sources with no new investment in additional coal generating capacity (though with existing coal plants continuing to operate). This can be achieved at minimal or zero cost to the Chinese economy but will not occur without a strong strategic focus and clear quantitative targets for clean power system-related investment within the 14th five-year plan and other policy documents.

This is because China's past policy of subsidising renewables via prices above the coal benchmark price has unleashed economies of scale and learning-curve effects. These have reduced the cost of both wind and solar to the point where they are now a cheaper way to meet growing electricity demand than new coal power plants in many provinces. It is therefore possible to phase out price subsidies to solar or onshore wind developments, which is happening this year.

However, the pace of renewables investment is still stymied by mistaken assumptions about limits to feasible renewable penetration within the power system; by misaligned provincial incentives which favour coal generation; and by inadequate investment in energy storage, long-distance transmission, and advanced forms of grid management. In addition, the experience of other countries shows that even when renewables reach cost parity, still lower costs are best assured by clear quantitative targets for renewable deployment, combined with competitive auctions to deliver further cost reductions.

However, China's current power system strategy does not include such medium- and long-term quantitative targets, and fails to describe a strategic vision for the zero-carbon electrification of the Chinese economy. Such a vision should be a crucial element within the 14th five-year plan and other planning documents and should be supported by:

- A clear vision for the growth of electricity demand which will and should occur over the next five years, as road transport, residential heating, and other economic activities are increasingly electrified, and as ICT development creates additional electricity demand

- Quantitative targets for new capacity investments in renewable energy, nuclear, and hydro, with wind and solar annual capacity increases growing from today's 25 GW and 30 GW to the sort of pace (about 80 GW) required to put China on a path to long-term decarbonisation[18]

- Investment in the UHV long distance transmission, local distribution grids, energy storage and digitally enabled grid management systems required to run a power system with an increasing percentage of variable renewable supply

- Actions to support electric vehicle charging infrastructure and technology development in batteries, heat pumps, and hydrogen electrolysis, to support deeper electrification of the economy

In addition to these measures, a medium-term strategy for zero-carbon electrification will require significant changes to the way in which China's power markets operate (supported by changes in regulations and governance), removing current biases against renewable development. The Energy Transitions Commission will be producing detailed recommendations on these changes during the course of 2020.

Zero-carbon electrification is vital not only in China but in many countries whose development is supported by China through its Belt and Road Initiative (BRI). China's domestic commitment to zero-carbon electrification should therefore be combined with the application of investment and lending criteria which encourage and support low-carbon development in BRI countries. In countries where the economic impact of COVID-19 creates the need for debt restructuring of BRI loans, China could consider supporting green development by making any debt restructuring contingent on the shift towards low carbon energy systems.

Three other pillars

2. Strengthen investment in "new" technology-based forms of infrastructure

As already committed to in the government work programme, China should invest in the new forms of information technology-based infrastructure which will support multiple forms of high-technology innovation. This will act as a strong growth engine to build a higher-value, more productive Chinese economy.

These investments are also closely linked to zero-carbon electrification. For while information and communication technology drives increased electricity demand, it also provides the tools to create a digitalised, interconnected and more efficient electricity system.

The digital transformation of the electricity system will enable multi-directional flows and an intelligent, integrated response to fluctuating supply and demand. A smart demand response system will provide flexibility and avoid unnecessary future spending on electricity infrastructure; effective management of the grid will enable more integration of renewable energy; and digitalisation will further unlock deep energy efficiency potentials in data centres, factories, and buildings.

Zero-carbon electrification and new infrastructure-based digitalisation are thus symbiotically linked; each makes the other more efficient and sustainable.

To strengthen the focus on "new" infrastructure investment, policy should:

- Support technology development and deployment via provincial investments
- Use local innovation funds to provide debt and equity for new infrastructure investment
- Create tight standards for energy intensity and carbon intensity for these new infrastructure areas
- Ensure electricity used for these new infrastructures will come from green and low-carbon energy sources

3. Ensure that investment in traditional infrastructure supports green and energy-efficient urbanisation

To avoid wasted investment and unnecessary carbon-intensive development, green and high-quality urbanisation should be another key element of the recovery package.

Such green urbanisation can deliver significant job creation in new construction, the retrofitting of existing buildings, and environmental improvement projects. It will create greener, more liveable cities and it can deliver major improvements in energy efficiency. For instance, green building codes which require stricter energy efficiency and which promote the electrification of heating could reduce energy consumption in buildings by as much as 50 to 60 percent between now and 2050.[19]

Greening the investment in traditional infrastructure can be achieved by:

- Realistically planning future needs for infrastructure growth and avoiding unnecessary spending that will create oversupply and wasted investment

- Increasing the percentage of green projects in provincial investment plans and developing carbon intensity and energy intensity targets for new projects

- Shifting to a more circular economy, in particular steel scrap recycling and plastic recycling to increase material utilisation rates and reduce emissions and waste

- In the building sector, create tighter building codes for carbon efficiency and energy efficiency

- In the transportation sector, design cities that support climate resilience, prevent sprawl and waste, and consider more strategic siting for newly-built distribution centres and logistics warehouses to reduce unnecessary travel mileage and reduce energy consumption

- Local government finance reform to reduce reliance on land sales and reduce the bias towards large infrastructure investments

4. Promote green consumption, with a strong focus on electrification

The policy package to drive a green recovery should also encourage green and efficient consumption, in particular by encouraging deeper and greener electrification.

For individual consumers, the most important potential lies in accelerating the electrification of road transport and space heating. Such an acceleration would:

- Deliver major improvements in energy efficiency and as a result in long-term living standards, given the inherent superior efficiency of electric engines and heating systems. Electric vehicle engines are three to four times as energy-efficient as internal combustion engines and heat pumps are three to four times more efficient than even the best gas or coal boilers

- Build Chinese industrial capabilities in key technologies which will be essential to competitive success in a world where many other countries are setting strong decarbonization objectives and imposing regulations and carbon prices which make high-carbon products uncompetitive

Specific policies for EV support include:

- Ensuring that short-term policies to encourage a revival in vehicle sales are skewed towards support for EVs, with purchase tax exemptions or other subsidies

- Exempting EVs from restriction policies, including by waiving license plate restrictions and congestion restrictions

- Accelerating investment in electric charging infrastructure and setting up zero-emission zones and parking spaces at city centres to spur the development of green and deeply electrified cities

Specific policies to encourage heat pump-based electrification of space heating include:

- When developing new residential and commercial building areas where geothermal and/or water resources are exploitable, supporting the application for ground/water source heat pumps in space heating

- Subsidising the application of air-source heat pumps and requiring the installation of heat pumps (rather than gas heating) in the building code in residential areas along the middle and lower reaches of the Yangtze river.

In addition, within the corporate sector the direct business purchase of zero-carbon electricity has major potential to deliver accelerated zero-carbon electrification and should be encouraged by appropriate power market design and improvements to the green electricity certificate system.

CONCLUSION

In response to the COVID-19 pandemic, China is at a crossroads and must grasp the opportunity to launch a green stimulus package, stimulating short-term economic recovery while building a long-term sustainable and high-quality growth future. The green recovery for China will also provide strong confidence to other countries that are still experiencing the spread of the virus and influence the policy choices they make in response to the economic recession following the pandemic.

An accelerated zero-carbon electrification system should be the central focus of China's recovery, supporting and supported by new digital infrastructure development, the greening of traditional infrastructure investments, and promotion of green consumption. A clean and electrified future will require partnership between government and the private sector to achieve the decoupling of economic growth and carbon emissions.

ENDNOTES

1. *Government Work Report*, May 22 2020, **http://www.gov.cn/guowuyuan/2020zfgzbg.htm**

2. National Bureau of Statistics, April 2020, **http://www.stats.gov.cn/**.

3. *World Economic Outlook Database*, International Monetary Fund, April 2019, **https://www.imf.org/external/pubs/ft/weo/2019/01/weodata/index.aspx**.

4. *Innovate China-New Drivers of Growth*, report of the World Bank and the DRC of the State Council, 2019, **https://openknowledge.worldbank.org/handle/10986/32351**

5. Richard Herd, *Estimating capital formation and the capital stock by economic sector in China*, September 2017

6. National Bureau of Statistics, April 2020, **http://www.stats.gov.cn/**.

7. *2019 China Urban Households Asset and Debt Survey,* People's Bank of China, April 2020

8. Yongding YU, *China's Non-financial Corporate Debt Dynamics*, China & World Economy (1-17, Vol. 24, No. 1,2016).

9. OECD Economic Surveys: China 2017

10. *BP Statistical Review of World Energy*, June 2019, **https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html**

11. National Bureau of Statistics, **http://www.stats.gov.cn/tjsj/ndsj/**

12. Chen K, Wang M, Huang C, Kinney PL, Anastas PT. *Air pollution reduction and mortality benefit during the COVID-19 outbreak in China*, Lancet Planet Health 2020, May 13.

13. *World Population Prospects 2019*, United Nations Department of Economics and Social Affairs, 2019, **https://population.un.org/wpp/Download/Standard/Population/**

14. *New Infrastructure White Paper*, China Centre Information Industry Development, April 2020, **http://www.ccidwise.com/plus/view.php?aid=16389&tyid=3**

15. *China 2050: A Fully Developed Rich Zero Carbon Economy*, Energy Transitions Commission, November 2019, **http://energy-transitions.org/china-2050-fully-developed-rich-zero-carbon-economy**.

16. Bloomberg New Energy Finance , 1 H 2020 LCOE update, **https://about.bnef.com/blog/scale-up-of-solar-and-wind-puts-existing-coal-gas-at-risk/**

17. *Lighten the green cloud: China data center energy consumption and renewable energy consumption potential research*, Greenpeace, North China Electric Power University, September 2019, **https://www.greenpeace.org.cn/wp-content/uploads/2019/09/点亮绿色云端：中国数据中心能耗与可再生能源使用潜力研究.pdf**

18. *2019 Renewable Energy Integration Status Report*, National Energy Administration, March 2020, **http://www.nea.gov.cn/**

19. *China 2050: A Fully Developed Rich Zero Carbon Economy*, Energy Transitions Commission, November 2019, **http://energy-transitions.org/china-2050-fully-developed-rich-zero-carbon-economy**.

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