Chemistry Sciences and Sustainable Development: A Roadmap for Future

Applications of Zeolites in Sustainable Chemistry

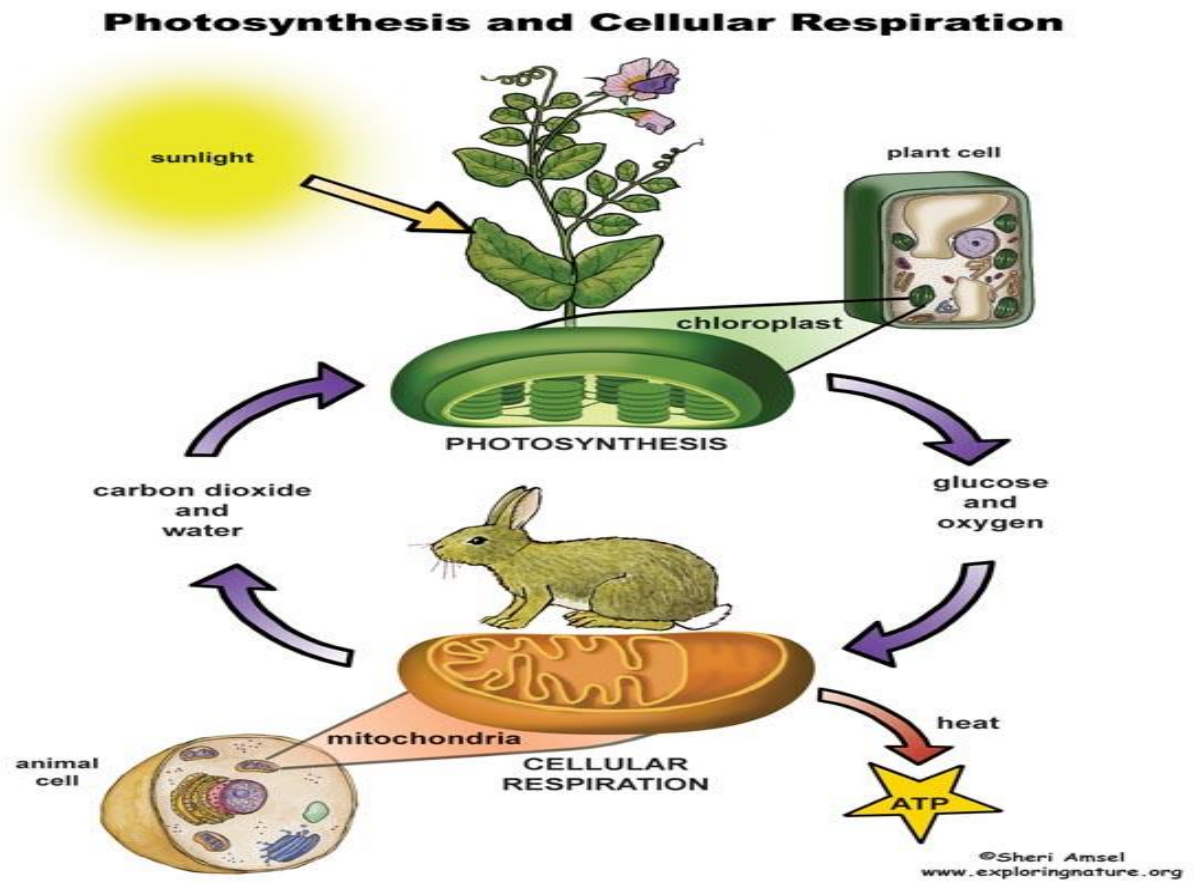
Chem. 3, 2017, Pages 928-949

علوم شیمی و نقش آن در توسعه پایدار: با اهداف اثربخشی نتایج پژوهش در جامعه

-احمد شعبانی، بهار ۱۴۰۰، جایگاه علوم شیمی و نقش آن در توسعه پایدار، فصلنامه نامه علوم پایه فرهنگستان علوم، شماره ۱، ص ۱۲-۲۴.

شاخص های توسعه پایدار در فرایندهای شیمیایی: فرایند های چرخه ای، همگرا، تجدید پذیر،کاهش یافته و کوچک، قابل بازیافت، قابل استفاده مجدد

فرایند چرخه ای فتوسنتز سلولی و تنفس سلولی: دو فرایند میرا در واگرایی، اما کیمیایی در چرخه ای و همگرایی و پایه حیات



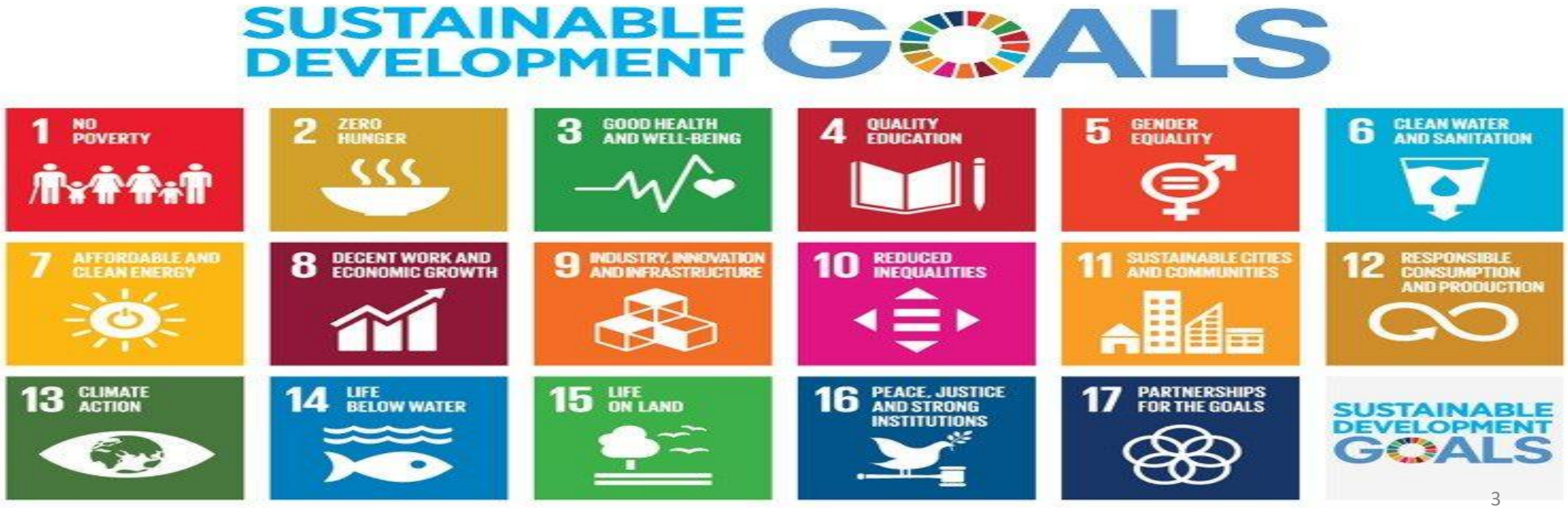
United Nations Development Programme

https://www.un.org/en

17 Goals to Transform Our World

The Sustainable Development Goals (SDGs) are a call for action by all countries – poor, rich and middle-income – to promote prosperity while protecting the planet. They recognize that ending poverty must go hand-in-hand with strategies that build economic growth and address a range of social needs including education, health, social

https://www.acs.org/content/acs/en/sustainability/chemistry-sustainable-development-goals.html



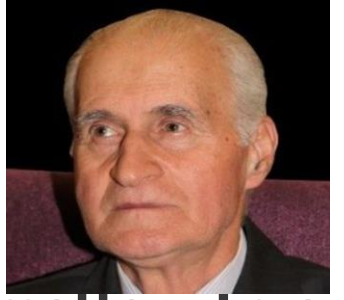
Which SDGs Are Most Relevant to Chemistry?

مجمع عمومی سازمان ملل متحد در یک ماموریت جهانی جمعی، برای دستیابی به آینده ای پایدار درکره زمین، برنامه توسعه پایدار 2030 میلادی را که پنج مورد کلیدی از اهداف آن شامل **امنیت غذایی، بهداشت و سلامت، آب سالم، انرژی پاک و تغییرات آب و هوایی،** می باشد به عنوان بخشی از چالش های اصلی جامعه جهانی معرفی کرده است. با توجه به اینکه پایه و بنیاد علمی همه این چالش ها عمدتا در حوزه علوم شیمی است، از جمله مطالبات جامعه جهانی از علوم شیمی، پاسخگویی به این چالش های پنجگانه است و انتظار می رود دانشمندان علوم شیمی نقش خود را به طور بایسته و شایسته انجام دهند.

- **Zero Hunger**
- **Good Health & Well-Being**
- **Clean Water & Sanitation**
- **Affordable & Clean Energy**
- **Industries, Innovation & Infrastructure**
- **Responsible Consumption & Production**
- **Climate Action**

Chemistry has a bright future for us and our economy

https://www.bio21.unimelb.edu.au/chemistry-has-bright-future-us-and-our-economy



Chemistry is the science of molecules: the basic building blocks of all known matter. In a way, this makes chemistry the science of everything. Chemists have shown that all the substances around us – the Earth and indeed the universe as a whole – are composed of just 92 building blocks or elements (not including several we have made ourselves, which don't appear in nature). In fact, just seven of these elements are responsible for more than 99% of the world around us.

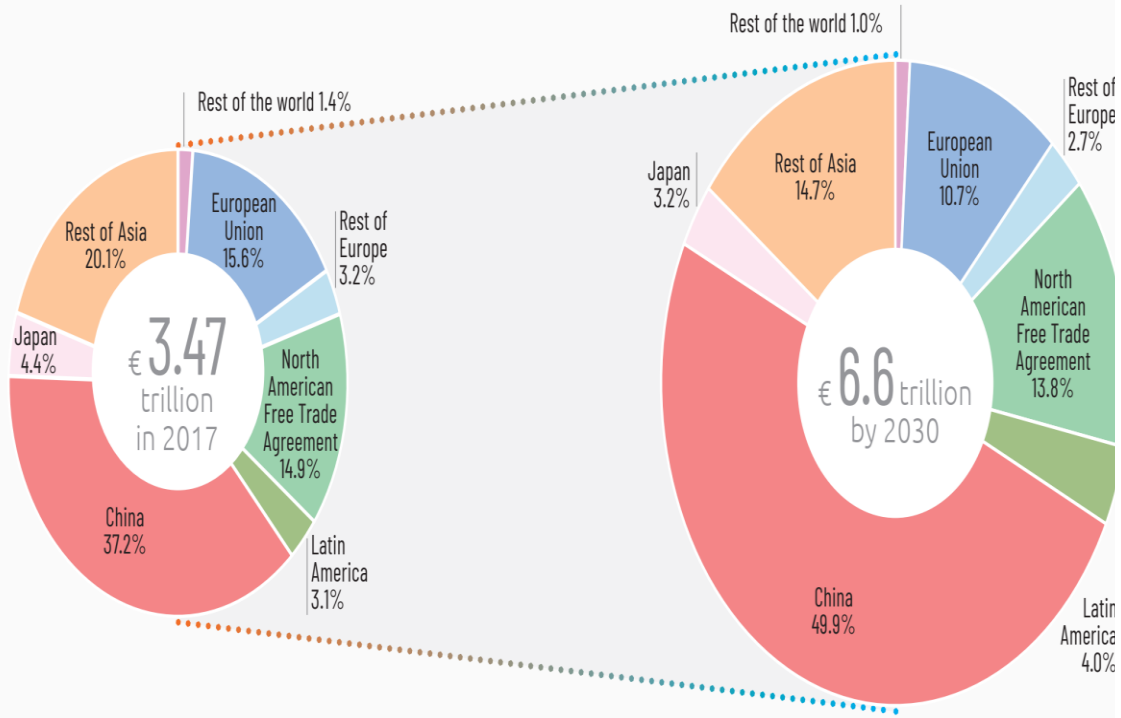
Chemical civilisation

Chemistry as a discipline also has been, and remains, a significant contributor to the wealth, prosperity and health of humanity. Over the last 5,000 years, it is chemistry, more than any other discipline, that has made our global civilisation possible. In 2014, the global chemicals industry contributed 4.9% of global GDP and the sector had gross revenues of US$5.2 trillion. That corresponds to US$800 for every man, woman and child on the planet. We anticipate that chemistry will continue to define the directions of technological change during the 21st century. For example, chemical research and development will contribute to energy efficient LEDs, solar cells, electric vehicle batteries, water desalination, biodiagnostics, advanced materials for durable clothing, aerospace, defence, agriculture, nanotechnology, additive manufacturing as well as health and medicine.

The production, use and trade of chemicals are growing in all regions

Between 2000 and 2017, the global chemical industry's production capacity (excluding pharmaceuticals) almost doubled, from about 1.2 to 2.3 billion tonnes. If pharmaceuticals are included, global sales totalled US dollars 5.68 trillion in 2017, making the chemical industry the world's second largest manufacturing industry.

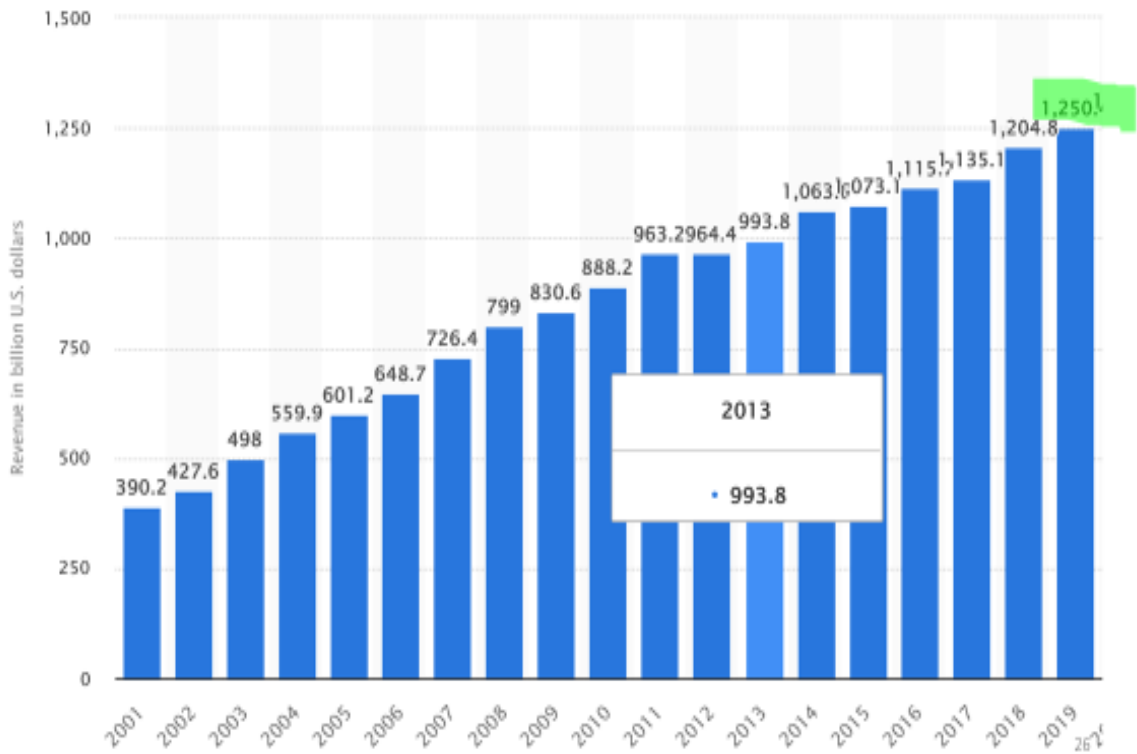
Figure 4 Projected growth in world chemical sales (excluding pharmaceuticals), 2017-2030 (adapted from European Chemical Industry Council 2018, p. 34)



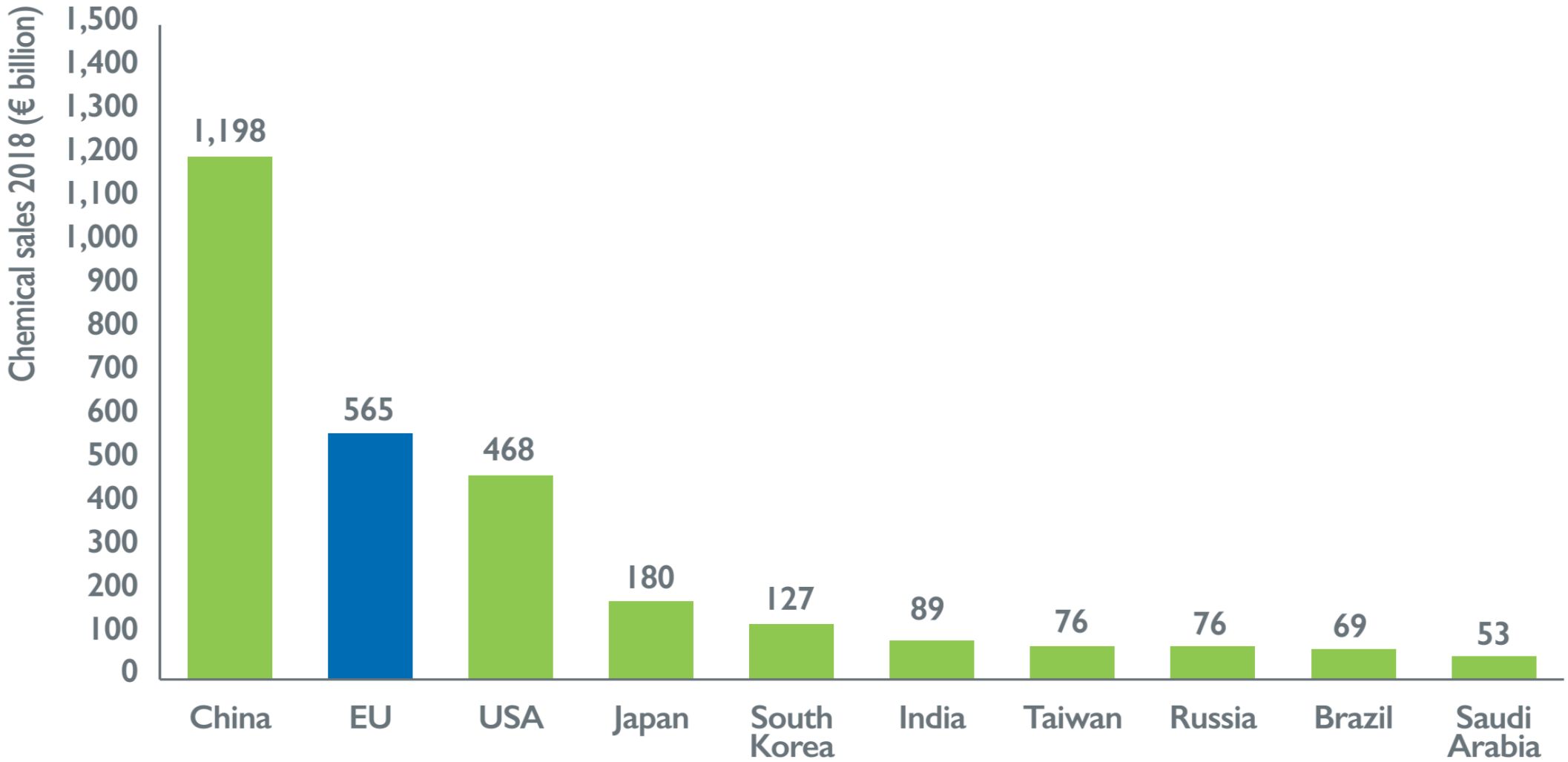
Global chemical sales (excluding pharmaceuticals) are projected to grow from EUR 3.47 trillion in 2 EUR 6.6 trillion by 2030. Asia is expected to account for almost 70 per cent of sales by then.

Revenue of the worldwide pharmaceutical market from 2001 to 2020

(in billion U.S. dollars)



Chemical sales by country: top 10



Future of the Chemical Sciences

Royal Society of Chemistry

https://www.rsc.org/globalassets/04-campaigning-outreach/campaigning/future-chemical-sciences/future-of-the-chemical-science-report-royal-society-of-chemistry.pdf

1. The role of the chemical sciences – essential and connected: Chemistry may need to be increasingly **interdisciplinary** and there could be a significant shift **from blue-skies** (The term blue skies research implies a freedom to carry out flexible, curiosity-driven research that leads to outcomes not envisaged at the outset.) **to problem-driven research.** There is a risk of chemistry turning into a "follower" discipline in discovery.

2. Future demand – chemistry for impact: It is likely the chemical sciences will be increasingly required **to solve challenges in energy and climate change, food production and clean water. Chemistry might have an increased role in biochemistry and the pharmaceutical industry,** as well as in the maintenance and development of infrastructure.

3. Funding structures, institutions and education – the need for change: There may be a need for change in government funding, towards more and better directed investment in chemistry. Chemistry education might need a more integrated approach that is increasingly hands-on and interdisciplinary.

4. Globalisation – collaboration and competition: There is likely to be global growth in demand for the chemical sciences, which might not necessarily result in a significant shift of chemistry to low-cost economies. It might be challenging for the UK to remain in the top tier of leading chemistry countries.

5. Technology – efficiency and innovation: Advances in technology are likely to remain a major trend, with far-reaching implications for the future of the chemical sciences. The nature of chemistry research, organisational structures and chemistry careers might need to change in response to these radical changes.

6. Openness – disruptive, inevitable and uncertain: Open data, open access and open content might drive collaboration, specialization and increased transparency, but the consequences are not fully understood.

7. Social change – changing workforce and public attitudes: Strong growth in demand for medicine for age-related conditions and changing demographics might lead to competition for talent and a new definition of talent that is more diverse and inclusive. There may be an increased public appetite for chemistry-related challenges with greater public intervention on how public money is spent.

ACS Chemistry Enterprise Partnerships & U.N. Sustainable Development Goals

https://www.acs.org/content/acs/en/global/international/alliances.html

- **Chemistry will play a critical part addressing many of the global challenges we face today. Each of the American Chemical Society's Chemistry Enterprise Partnerships (CEPs) center around one or more U.N. Sustainable Development Goals (SDGs). In utilizing the SDGs as a partnership framework, ACS and our partners are prepared to focus collaborative activities, and create a larger impact on chemistry while also advancing the 2030 Agenda for a more sustainable world. For more information on ACS's role in contributing to the U.N. SDGs, please visit the ACS Green Chemistry Institute.**
- **While the chemical sciences can be used to address all of the SDGs, below are a few highlighted Goals that ACS has identified that the Society and its partner organizations might have the greatest impact at addressing through collaborative activities:**
- **Goal 2: Zero Hunger - End hunger, achieve food security and improved nutrition and promote sustainable agriculture.**
- **Goal 3: Good Health & Well-Being - Ensure healthy lives and promote well-being for all at all ages.**
- **Goal 4: Quality Education - Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.**
- **Goal 5: Gender Equality - Achieve gender equality and empower all women and girls.**
- **Goal 6: Clean Water and Sanitation - Ensure availability and sustainable management of water and sanitation for all.**
- **Goal 7: Affordable and Clean Energy - Ensure access to affordable, reliable, sustainable and modern energy for all.**
- **Goal 12: Responsible Consumption and Production - Ensure sustainable consumption and production patterns.**
- **Goal 13: Climate Action - Take urgent action to combat climate change and its impacts.**
- **Goal 17: Partnerships for the Goals - Strengthen the means of implementation and revitalize the global partnership for sustainable development.**

The decadal plan for Australian chemistry 2016–25

Decadal plans are 10-year strategic plans for science disciplines, and are developed by the Academy's National Committees for Science.

https://www.science.org.au/supporting-science/science-sector-analysis/decadal-plans-science/decadal-plan-chemistry/decadal-pl-0

1. increasing agricultural productivity
2. conserving scarce natural resources through alternative materials and new processes to extract valuable materials from untapped sources
3. converting biomass feedstock through the development of bio refineries, using different types of biomass to provide energy, fuel and a range of chemicals with zero waste
4. developing diagnostics for human health to enable earlier diagnosis and improved disease monitoring
5. improving drinking water quality through new technologies
6. synthesizing new drugs to transform drug discovery, that can deliver new therapies more efficiently and effectively
7. improving energy conversion and storage
8. harnessing nuclear energy safely and efficiently by developing fission and investigating fusion technologies
9. improving solar energy technology, yielding more cost efficient processes and developing the next generation.
10. designing sustainable products that take into account the entire life cycle of a product during initial design decisions to preserve valuable resources.

The Role of Chemical Societies & the United Nations Sustainable Development Goals (SDGs)

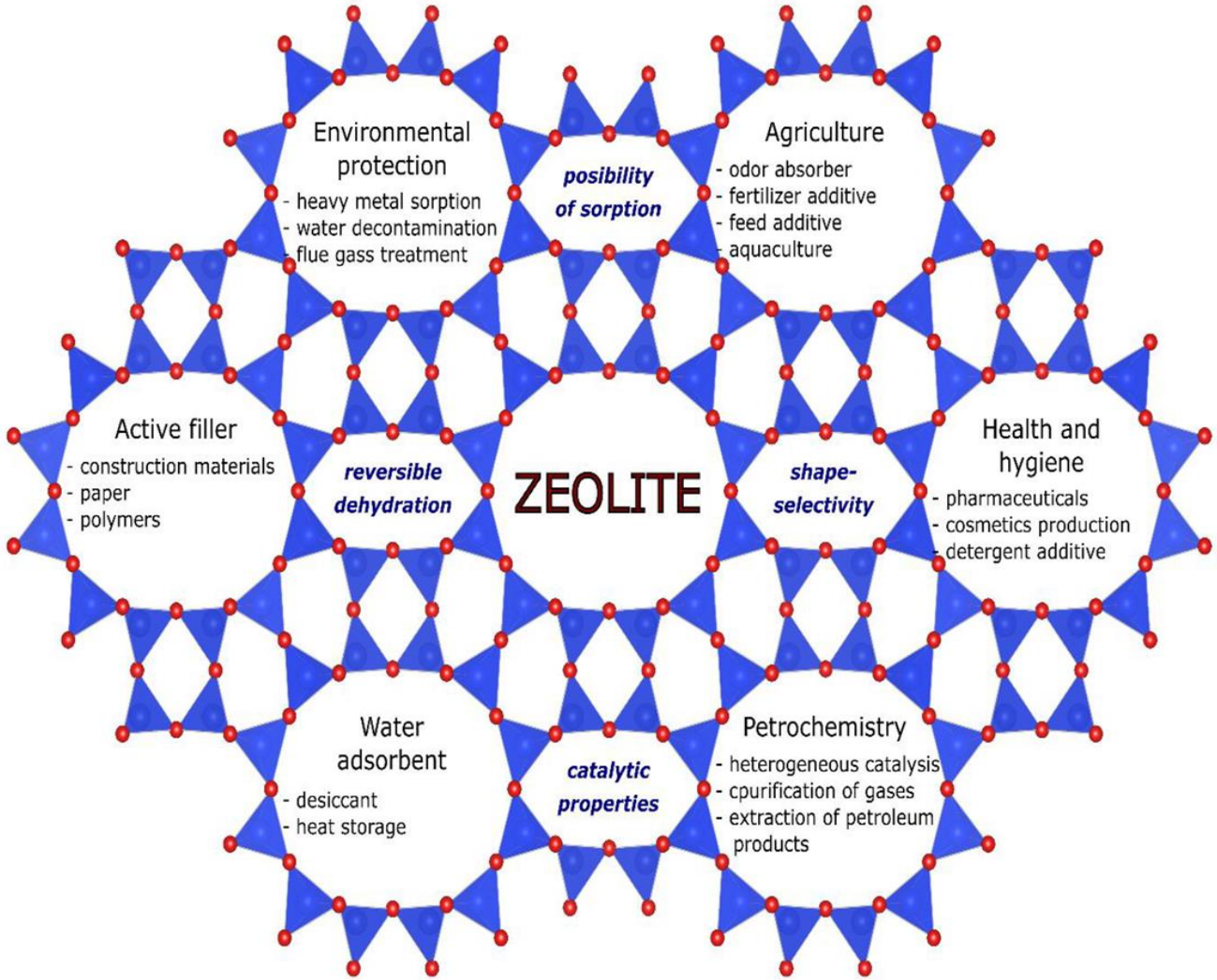
- **Leaders from ACS and the German Chemical Society (GDCh) have signed a five-year partnership agreement outlining future collaboration in advancing the United Nations Sustainable Development Goals (SDGs).**

https://www.acs.org/content/acs/en/sustainability/chemistry-sustainable-development-goals.html

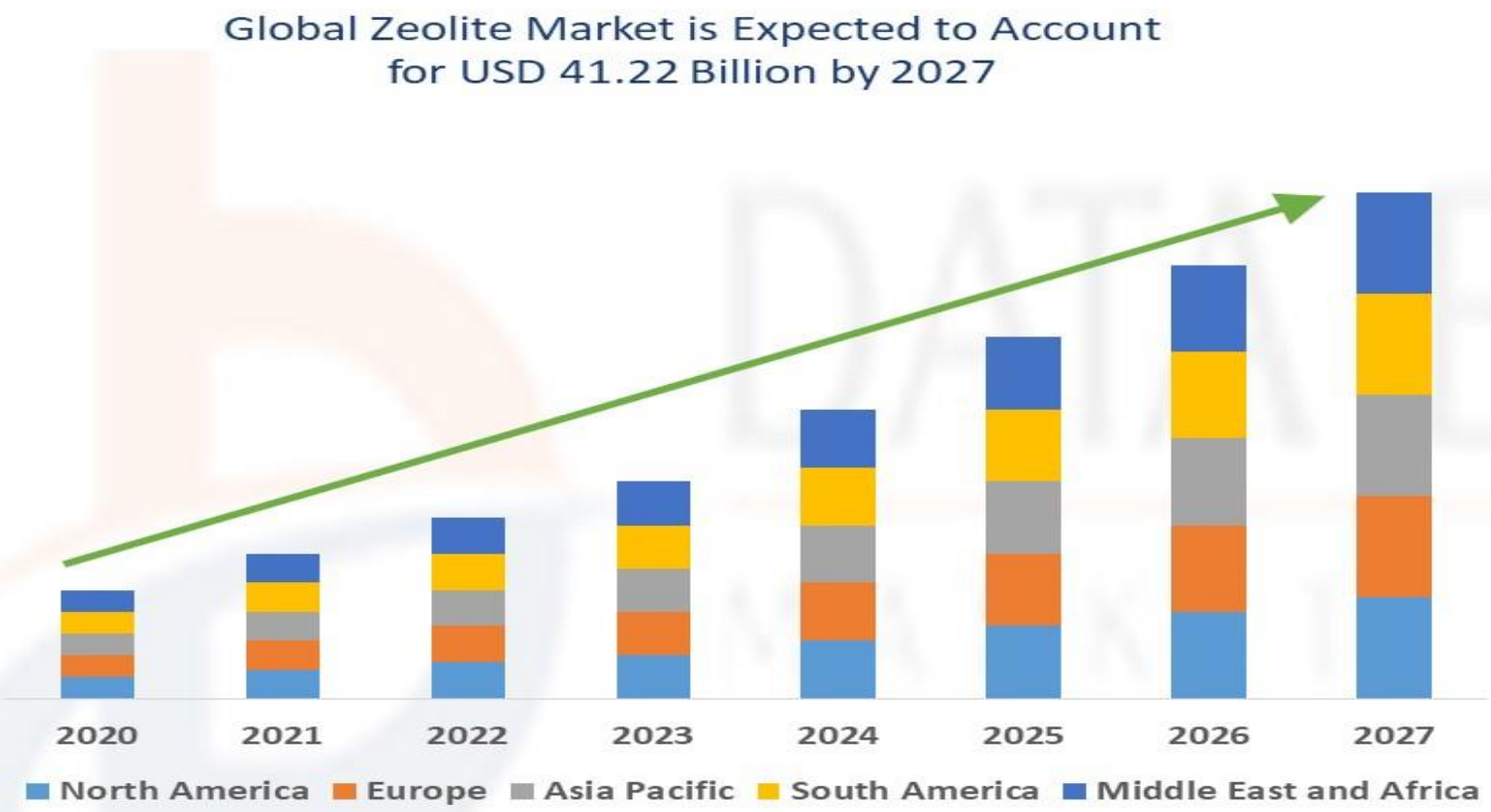
Applications of Zeolites in Sustainable Chemistry

Chem. 3, 2017, Pages 928-949

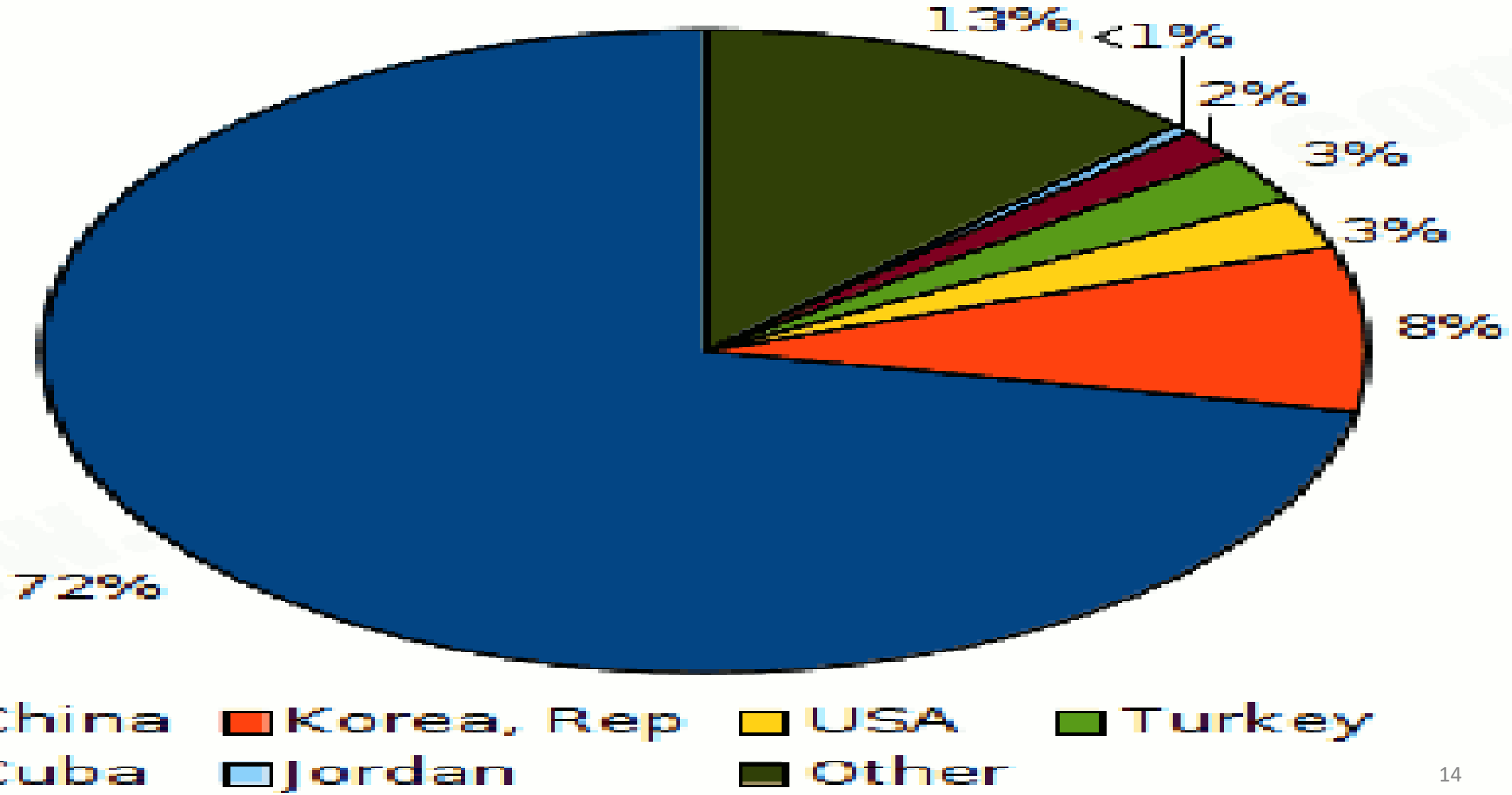
-احمد شعبانی، خرداد ماه ۹۷ :مولکول هایی که آینده را تغییر خواهند داد "، نشریه نشا علم. سال هشتم شماره دوم، ص ۹۹-۱۱۰



جایگاه ایران صرفا بر اساس درصد جمعیتی باید 400.000.000 دلار باشد!



Where do natural zeolites come from? Estimated world mine production for 2015. China produced almost three quarters of all natural zeolites (2 million tons) [7]. Total world reserves of zeolites are unknown "but are estimated to be large"



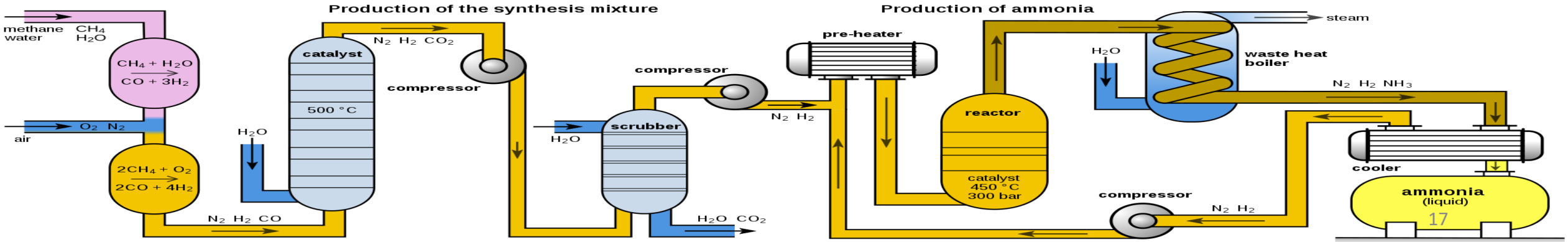
• Hide Section Sustainable Development Goal 2: Zero Hunger

There are many examples of how chemistry will help society achieve the Zero Hunger goal. Advances in chemistry will help to better protect plants from pest infestations, improve food production and distribution channels, extend the shelf life of food through advances in packaging, and maintain food quality and safety. High-yield seeds in combination with new approaches to fertilization will increase food production and help to reduce soil erosion. Fortification of food will help combat malnutrition in areas with limited access to healthy foods. Technologies for sustainable ammonia production, for phosphate recovery and reuse, and for targeted crop protection agents are additional examples of significant opportunities for the chemistry enterprise to make positive contributions.

More than 40% of the world's food supply depends on the production of chemical fertilisers. CREDIT: CSIRO/GREGORY HEATH

The Haber process, also called the Haber–Bosch process, is an artificial nitrogen fixation process and is the main industrial procedure for the production of ammonia today.

-Haber and Bosch were awarded Nobel prizes, in 1918 and 1931 respectively.
-The major source of hydrogen is methane from natural gas.
-The Haber process consumes 3–5% of the world's natural-gas production and around 1–2% of the world's energy supply.
-With average crop yields remaining at the 1900 level, the crop harvest in the year 2000 would have required nearly four times more land, and the cultivated area would have claimed nearly half of all ice-free continents, rather than under 15% of the total land area that is required today.
-Nearly 50% of the nitrogen found in human tissues originated from the Haber–Bosch process.
-Disruption to the nitrogen cycle.
-Leaching of nitrates into ground water, rivers, ponds and lakes; expanding dead zones in coastal ocean waters, resulting from recurrent eutrophication; atmospheric deposition of nitrates and ammonia affecting natural ecosystems; higher emissions of nitrous oxide (N_2O), now the third most important greenhouse gas following CO_2 and CH_4.

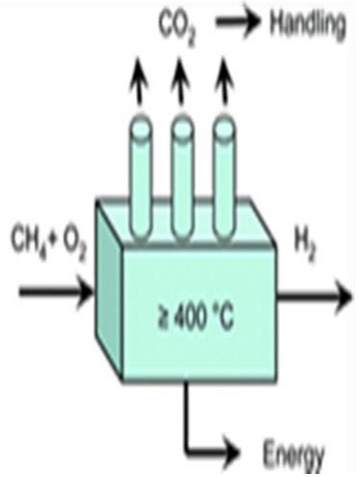


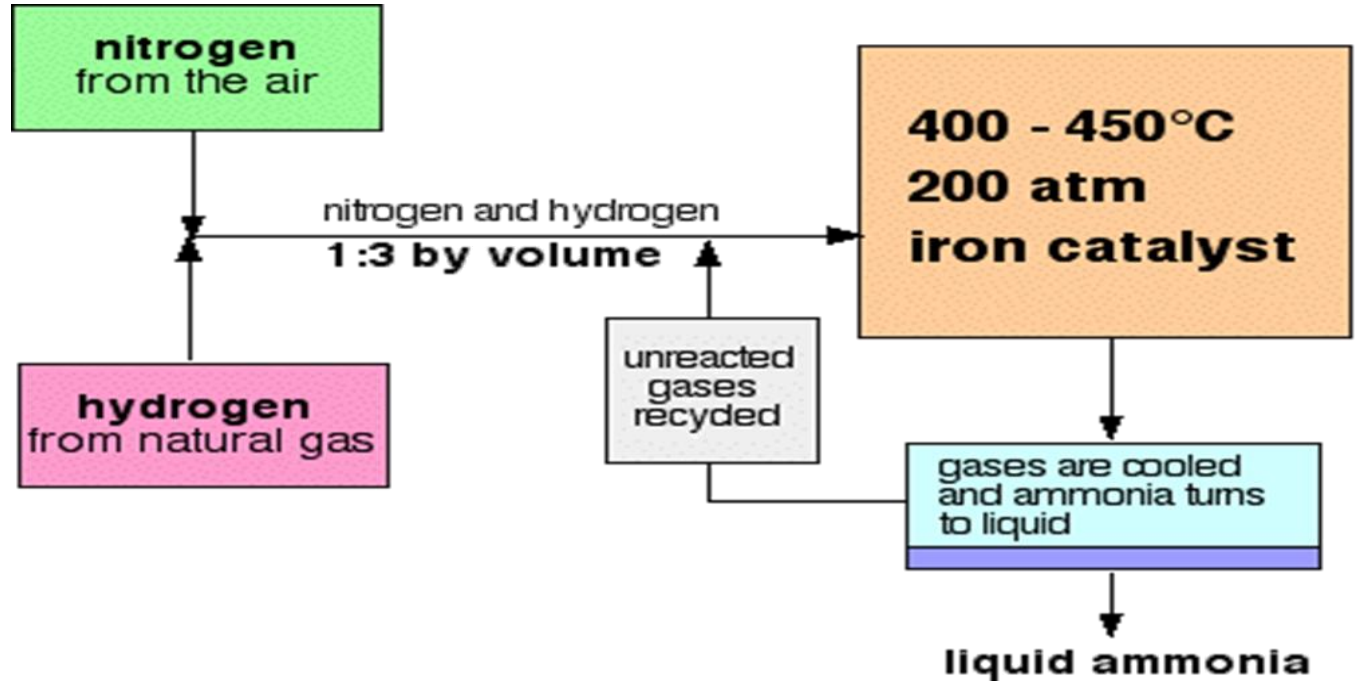
$$CH_{4(g)} + 2O_{2(g)} \rightarrow CO_{2(g)} + 2H_2O_{(g)}$$

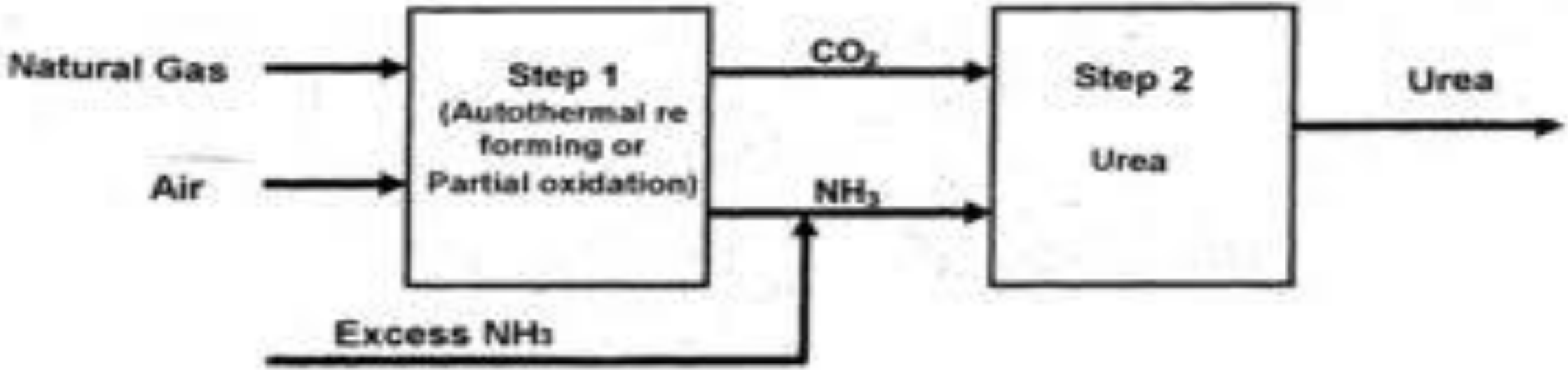
$$CH_{4(g)} \rightarrow C_{(s)} + 2H_{2(g)}$$

$$C_{(s)} + O_{2(g)} \rightarrow CO_{2(g)}$$

$$2CH_{4(g)} + 3O_{2(g)} \rightarrow 2CO_{2(g)} + 2H_{2(g)} + 2H_2O_{(g)}$$



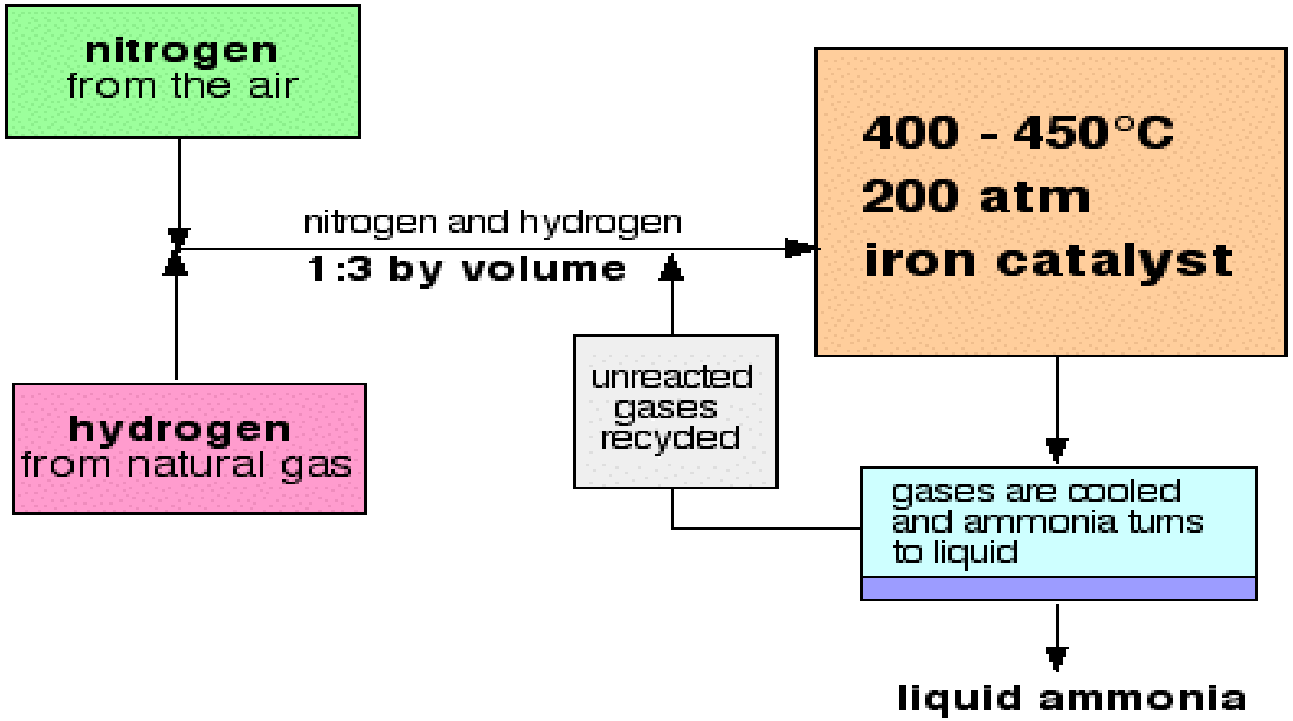




فرایند هابر- بوش در تولید آمونیاک از گازهای نیتروژن و هیدروژن در حضور کاتالیست پایه آهن :

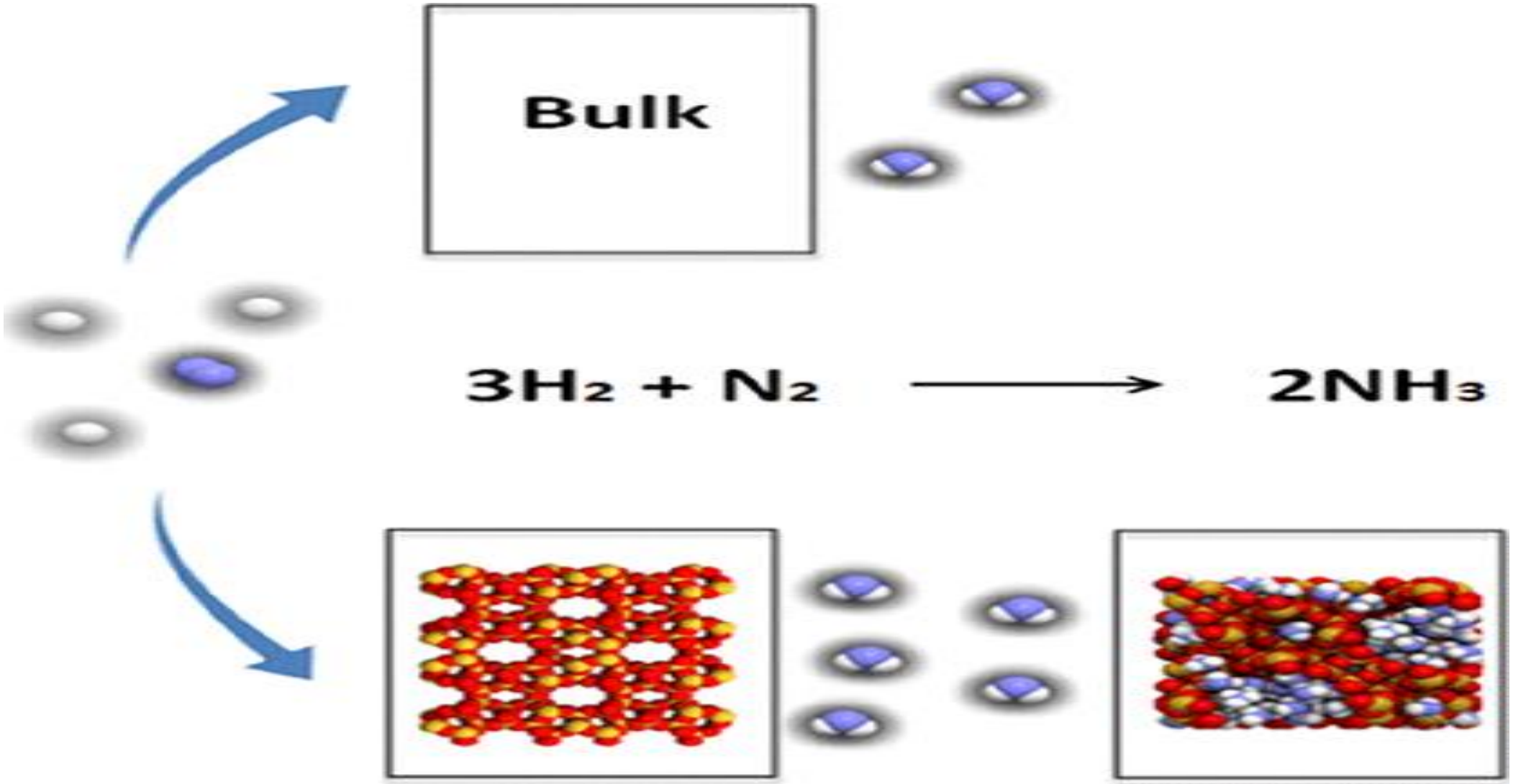
گاز هیدروژن مورد نیاز این فرایند تحت شرایط نسبتا سخت و طی یک واکنش گرماگیر از متان تولید می شود. در ضمن حدود یک الی دو درصد از کل انرژی مصرفی در جهان به این فرایند اختصاص می یابد.

در طی فرایند تبدیل متان به هیدروژن مقدار زیادی دی اکسیدکربن تولید می شود که مقدار آن در سال ۲۰۱۵ میلادی حدود ۷۰ میلیون تن گزارش شده است.



Improving Ammonia Production Using Zeolites

J. Phys. Chem. C 2019, 123, 30, 18475–18481
https://doi.org/10.1021/acs.jpcc.9b05366



- **Sustainable Development Goal 3: Good Health & Well-Being**

Chemistry is key to achieving the Good Health and Well-Being goal. Medical breakthroughs and technologies made possible through advances in chemistry provide a deeper understanding of how human health is impacted by disease and hazardous chemicals in our food, water and the environment. Chemistry plays a critical role in medical diagnosis and drug development, enabling people to live longer and healthier lives. Chemistry also offers new solutions for reducing pollution and its impacts on human health. The application of green and sustainable chemistry can help eliminate or reduce hazardous chemical pollution.

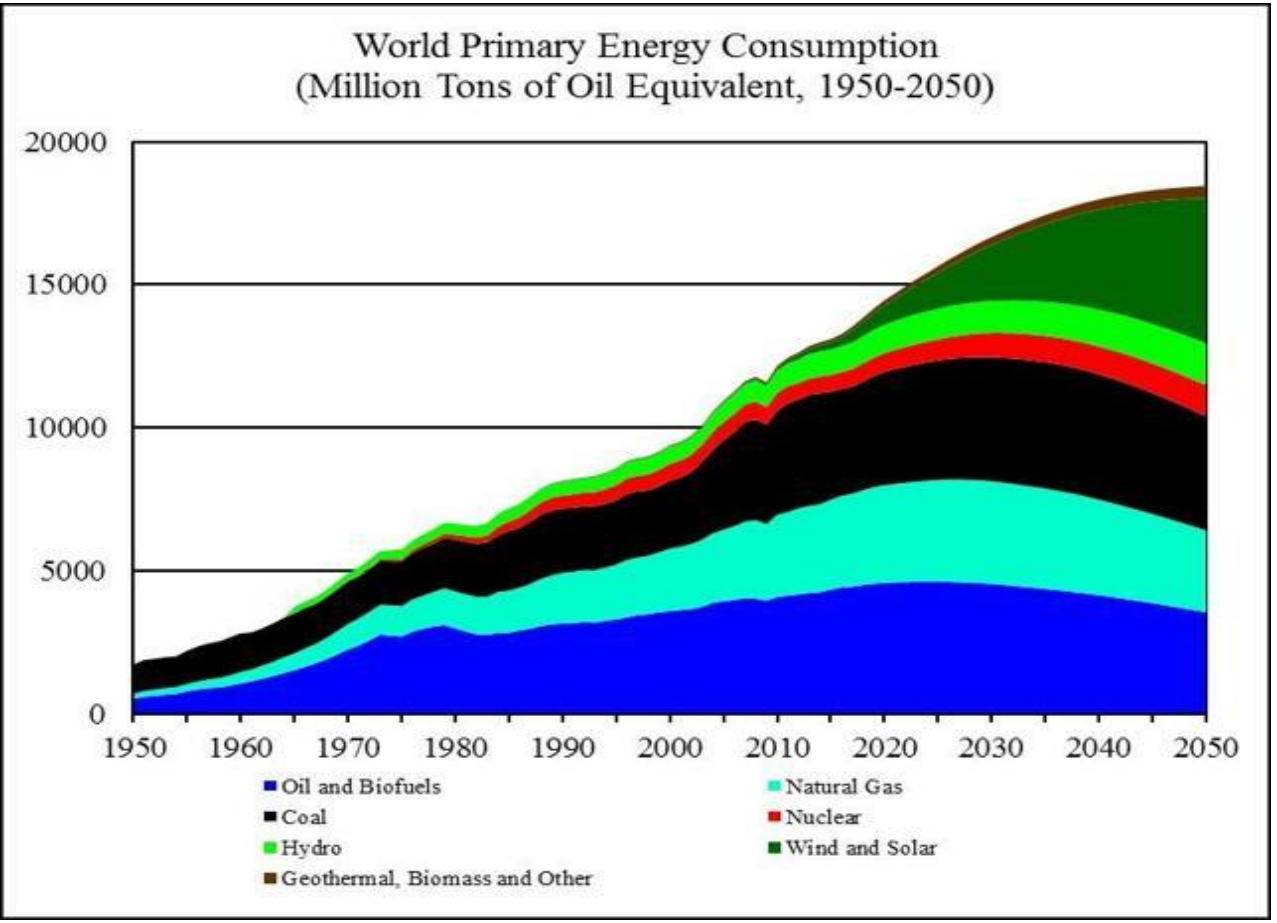

Alzheimer's Disease
Anti-cancer Activity
Nanomedicine
MRI Contrasting Agent
Antibacterial Activity
Hemodialysis

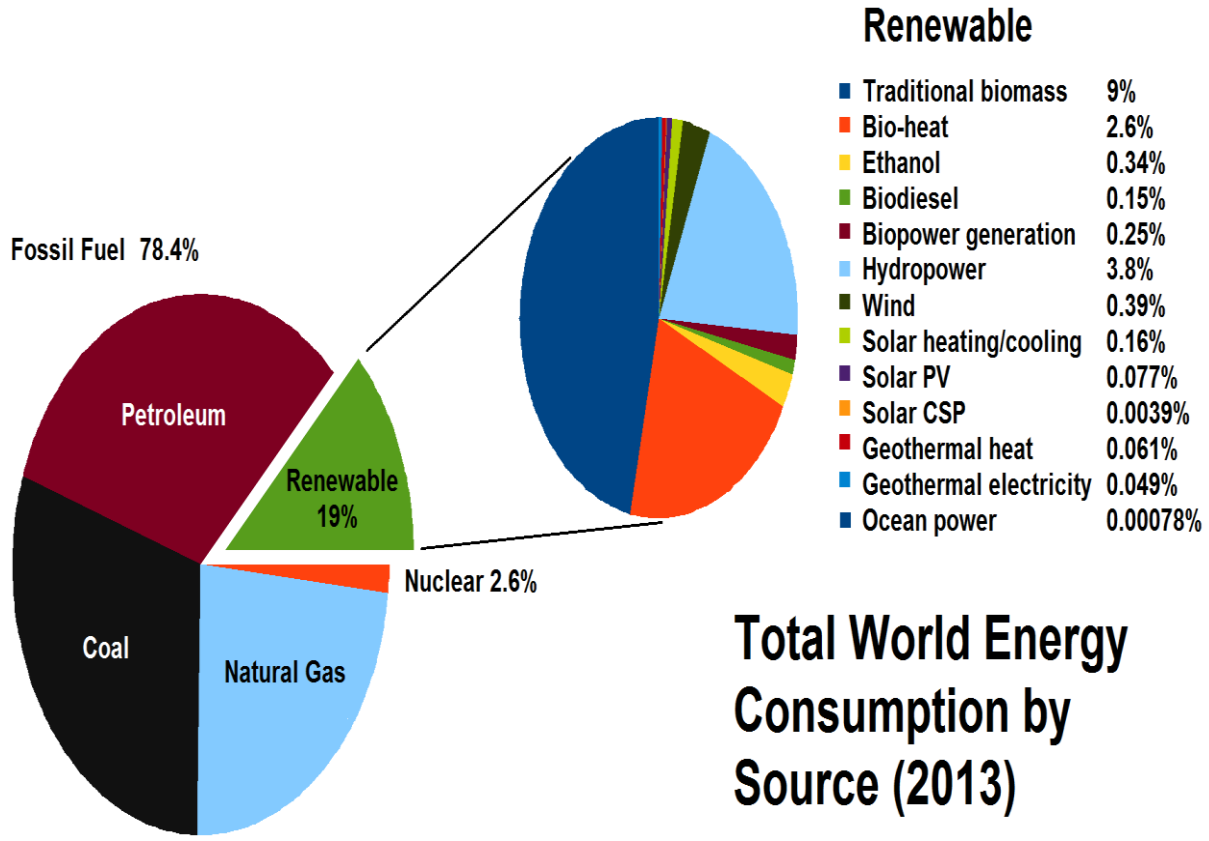
- **Sustainable Development Goal 7: Affordable & Clean Energy**

Chemistry will help meet the Affordable and Clean Energy goal through the development of new materials for renewable energy, by being more energy efficient in the chemical processing industries, and by advancing cleaner fuel technologies. A major issue with renewable energy production is the use of scarce and/or hazardous materials for solar and wind conversion, and energy storage. Chemical researchers are working on the development of Earth-abundant advanced materials for renewable energy production, including photovoltaics, wind turbines, thermal energy collection, batteries, supercapacitors and energy storage solutions. The chemical processing industries can improve manufacturing efficiency through new catalysts, optimized process design, and new separations processes.

-تامین ۸۰ درصد منابع انرژی جهان از سوخت های فسیلی که با تولید حجم وسیعی از گازهای گلخانه ای همراه است.

-محدودیت و تجدید ناپذیری سوخت های فسیلی و نیاز روز افزون و نمایی به انرژی(پیش بینی می شود بر اساس میزان مصرف و ذخایر شناخته شده فعلی، نفت خام در سال ۲۰۵۲ و گاز در سال ۲۰۶۰ به پایان برسد-لذا باید دنبال انرژیهای تجدید پذیر رفت).





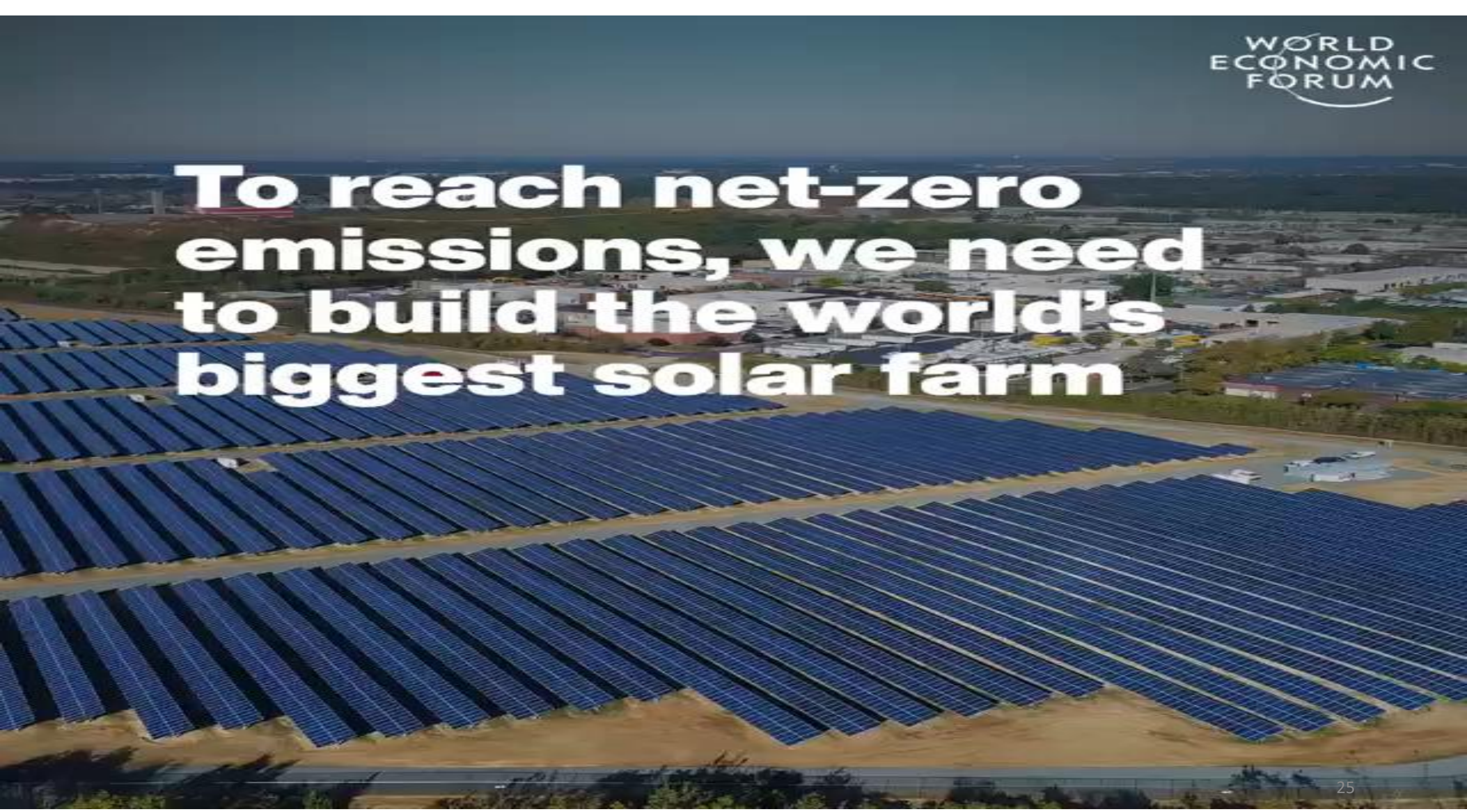
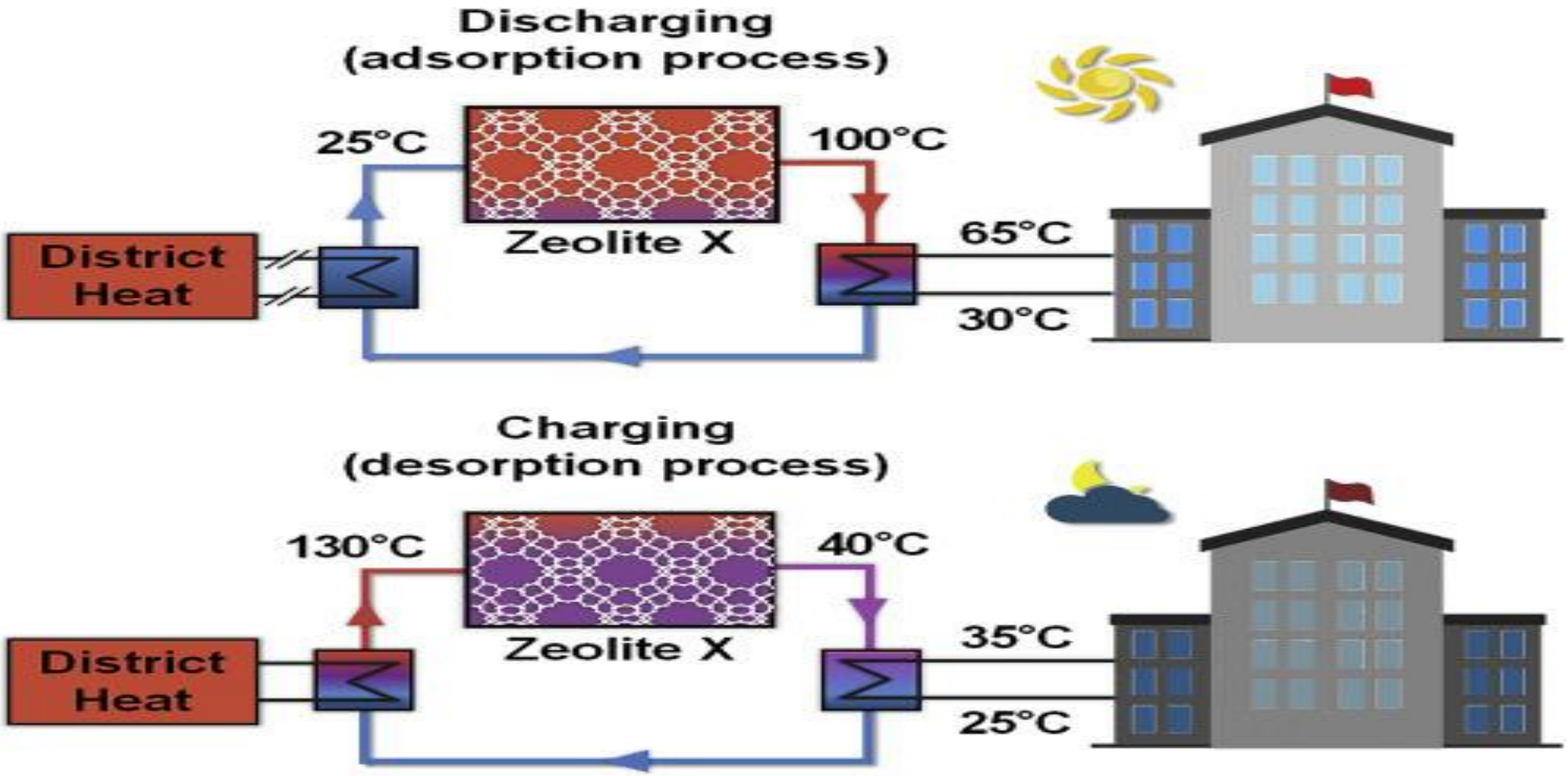

WORLD ECONOMIC FORUM
To reach net-zero emissions, we need to build the world's biggest solar farm

Table 1. Selected Examples of CO_2 Conversion over Zeolite Catalysts

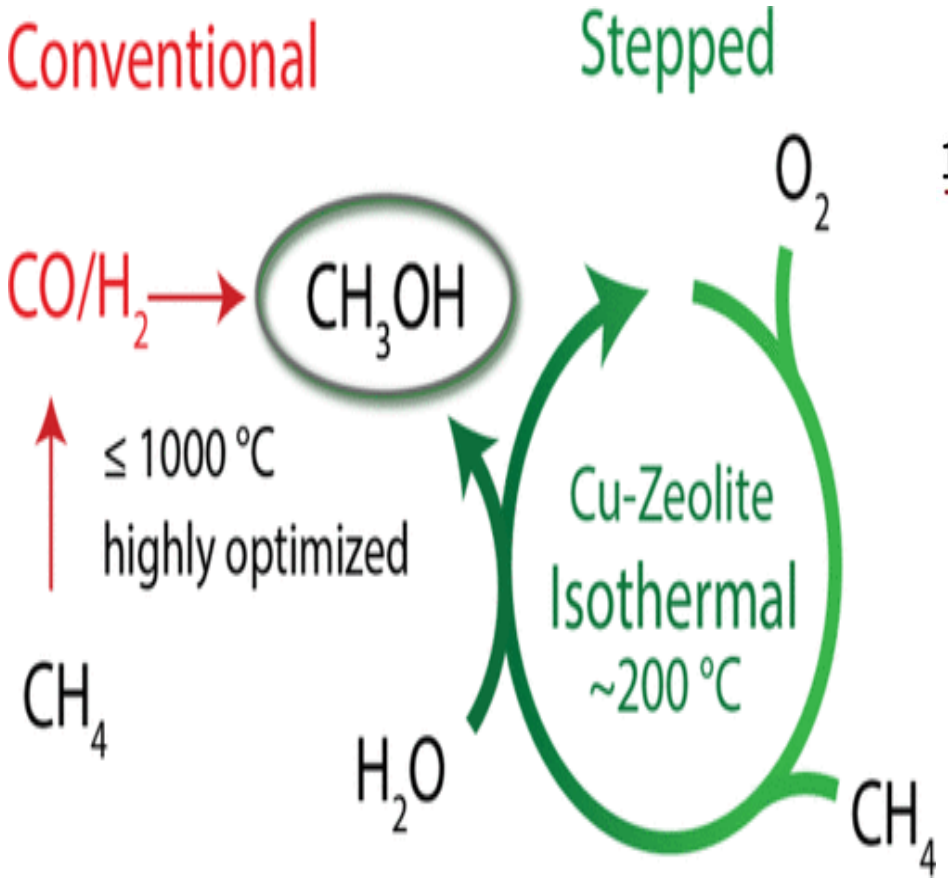
Catalyst	Reactants	Main Products	Reference
Ti/H-ZSM-5	CO_2, H_2O	CO	Tong et al.[44]
Ni/H-USY	CO_2, H_2O	CH_4	Westermann et al.[45]
Cu-ZnO/H-ZSM-5	CO_2, H_2	CH_3OH	Ayodele[46]
Zn/H-ZSM-5	CO_2, CH_4	CH_3COOH	Wu et al.[47]
CuO-ZnO-ZrO_2/H-ZSM-5	CO_2, H_2	CH_3OCH_3	Frusteri et al.[48]
Ion-liquid- or amine-functionalized ZSM-5	epoxide (epichlorohydrin)	cyclic carbonate (chloropropyl carbonate)	Sarmah and Srivastava[49]
CuO-ZnO-Al_2O_3/H-beta	CO_2, H_2	CO, C_2–C_4 hydrocarbons	Fujiwara et al.[50]
Na–Fe_3O_4/H-ZSM-5; In_2O_3/H-ZSM-5	CO_2, H_2	C_{5+} hydrocarbons	Wei et al.,[51] Gao et al.[52]

Zeolite/Water-Adsorption Energy Storage System for School Heating

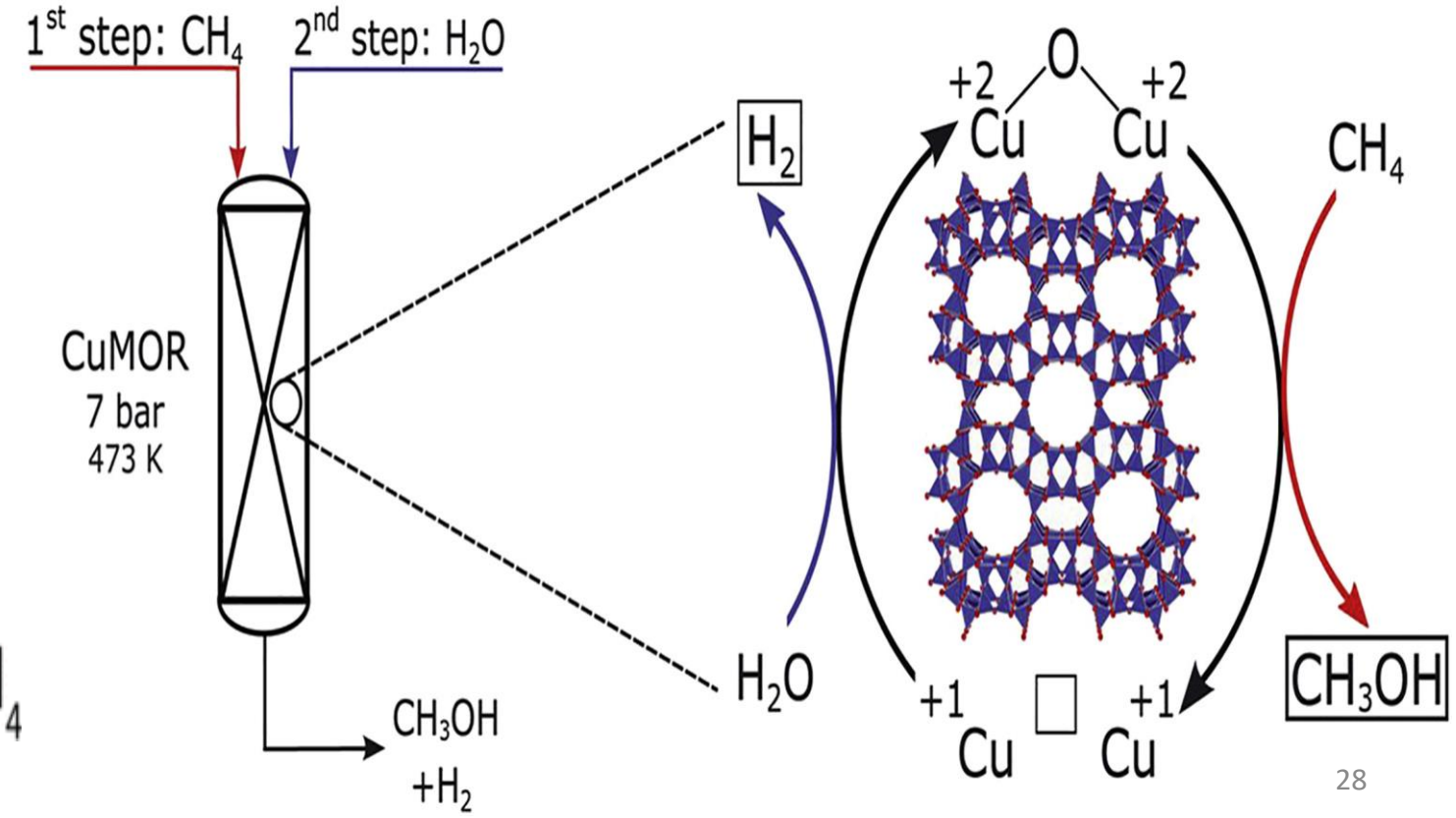
During the day, heat was released when water was adsorbed in zeolite X. Water was desorbed atnight by district heat, thereby regenerating the adsorption energy storage system.



Direct Conversion of Methane to Methanol under Mild Conditions over Cu-Zeolites and beyond
Acc. Chem. Res. 2017, 50, 2, 418–425



Two-Step Methane-to-Methanol Conversion
Using Water as Oxidant over Cu-Mordenite



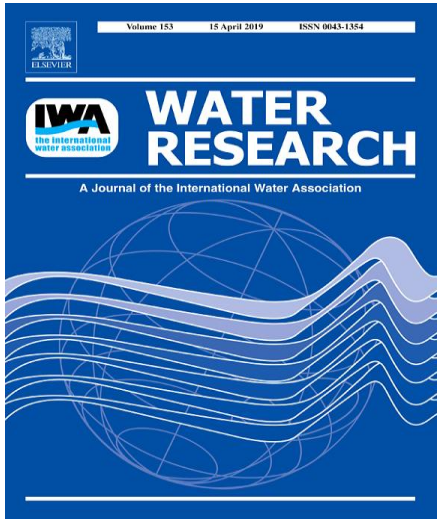
- **Sustainable Development Goal 6: Clean Water & Sanitation**

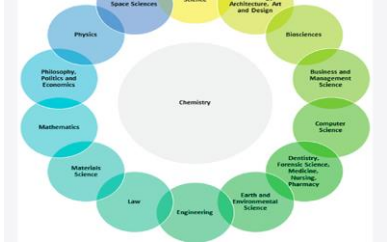
Chemists will help society meet the clean water and sanitation goal in several ways. New methods of water purification and lower cost desalination processes will contribute to achieving universal access to safe and affordable drinking water. Water quality will improve through the deployment of greener technologies and pollution prevention strategies. Research is also needed to find new low-energy, high-efficiency separation methods for removal of metals and micropollutants. The chemical industry can work toward manufacturing practices that minimize water usage and waste management practices that avoid pollution; international partnerships will be crucial to ensure that new technologies and water management strategies will benefit the entire planet.

- **Examples of Chemistry & Chemical Technologies to Meet This Goal:**
- **Solar assisted desalination processes**
- **Heavy metal removal**

مهمترین موضوع چالشی و حوزه پژوهشی در آینده-آب

با افزایش گازهای گلخانه ای و تغییرات آب و هوایی و گرمایش زمین پیش بینی می شود، یکی از بزرگترین چالش های فراروی بشر در آینده کمبود و بحران آب شیرین باشد. لذا، امروز باید در طراحی و اختراع روشهای کاتالیستی به منظور کاهش انرژی در تبدیل آبهای شور به شیرین پیشگام بود و پیش بینی می شود در آینده این حوزه تبدیل به یکی از مهمترین موضوعات پژوهشی شود.





نتیجه گیری

-شیمی به عنوان مرکز ثقل علوم، نقش برجسته ای در تولید ثروت دارد.

-حوزه های تحقیقاتی بهداشت و سلامت، انرژی پاک، تغییرات آب و هوایی، آب سالم و امنیت غذایی در راستای برنامه مجمع عمومی سازمان ملل متحد -۲۰۳۰ نقشه راه جامعه شیمیدانان اغلب کشورهای توسعه یافته و در حال توسعه می باشد. لذا پیشنهاد می شود انجمن شیمی ایران نیز با تدوین نقشه راه فعالیت در این حوزه ها را برای شیمیدان ها برجسته کند.

-با توجه به منابع معدنی فراوان زئولیتی در کشور و کاربرد چند منظوره و چند کاره آنها در گستره وسیعی از صنایع شیمیایی، کشاورزی، دارویی، کاتالیستی، و... ، پیشنهاد می شود وزارت صمت حمایت های ویژه از پروژهای زئولیتی به عمل آورد.
-پیشنهاد می شود پژوهشگاه شیمی و مهندسی شیمی ایران قطب علمی زئولیت را با حمایت وزارت صمت ایجاد کند.

و من اللّه التوفیق

منظره ای از دانشگاه شهید بهشتی