The Future of Geothermal

Research, intelligence, and insights on geothermal technology, costs, applications, and implementation

Multi-Client Study Prospectus

ADI Analytics
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Outline

- **Study Prospectus**
- About ADI

ADI's new study will analyze geothermal energy technologies, projects, costs and economics, and its outlook

Multi-client study drivers

- Decarbonization and energy security are two major themes of the energy transition.
- Geothermal energy offers a renewable power source without the intermittency issues of wind and solar.
- It is estimated that 0.1% of earth's heat could conceptually supply all of humanity's energy needs for 2 million years.
- Geothermal is seeing increased investments from the private and public sectors with new companies and technologies emerging to advance the industry.
- The geothermal industry is looking at incorporating tools and technology from the shale revolution to propagate and advance geothermal.

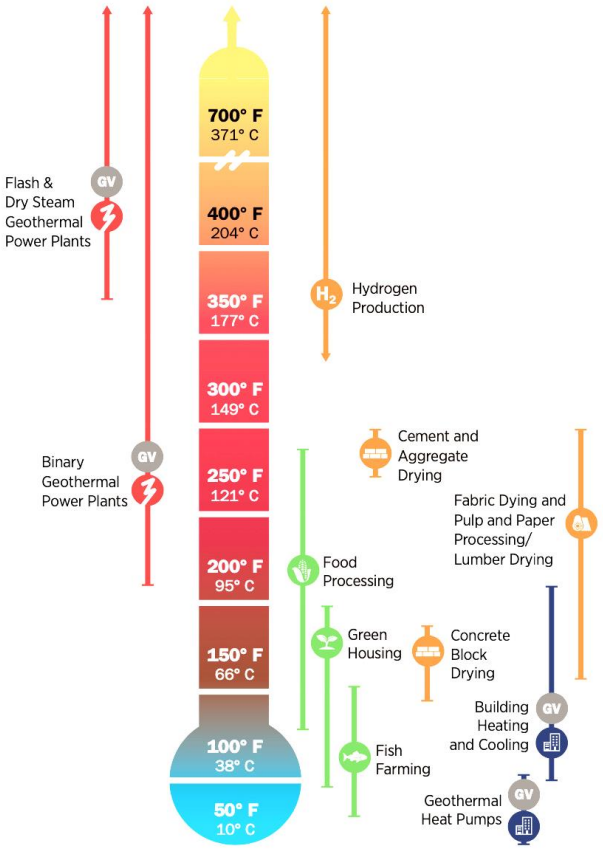
Strategic questions for the ADI study

- What is the state of the geothermal industry?
- What advances are being made in technology, and how are they improving costs?
- What longer-term technology challenges remain?
- Who is playing in this space, both developing technology and implementing projects?
- What geothermal projects are being developed, and what challenges are they facing?
- What environmental and regulatory challenges are affecting the industry?
- Where is geothermal headed over the next decade?
- What are the strategic implications and associated risks and uncertainties for current and new participants?

This report focuses on geothermal for power generation with some coverage at a high level of other applications

Power generation

- Power generation requires higher temperatures – typically above ~100 °C
- Older generations of geothermal power plants used steam directly from the ground and require heat of at least 200 °C
- Newer “binary” plants pass fluids through a heat exchanger and then use heat to flash steam



Direct use

- Geothermal heat can be used directly in residential, commercial, and industrial applications
- Applications include heating homes and buildings to drying cement and concrete
- Higher temperature geothermal can also be used for hydrogen production

Other applications

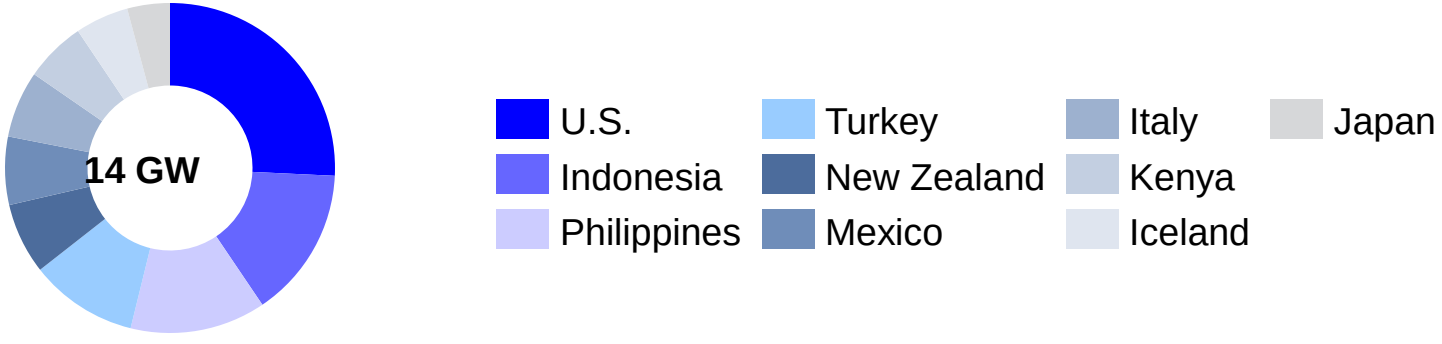
- Geothermal resources are increasingly being looked at for lithium extraction
- Process includes extracting lithium from geothermal brine before recirculating into the subsurface

Source: Geovision

Geothermal is a minor part of the renewable energy mix today, largely due to limitations with conventional technology …

Location of geothermal power plants

Top 10 geothermal producing countries

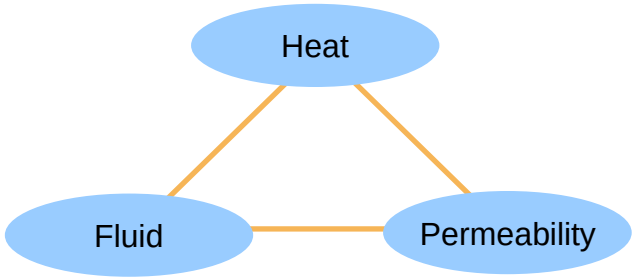


Source: thinkgeoenergy.com, NREL, ADI Analytics

… Although conventional geothermal is cost-competitive when compared to other renewable power technologies

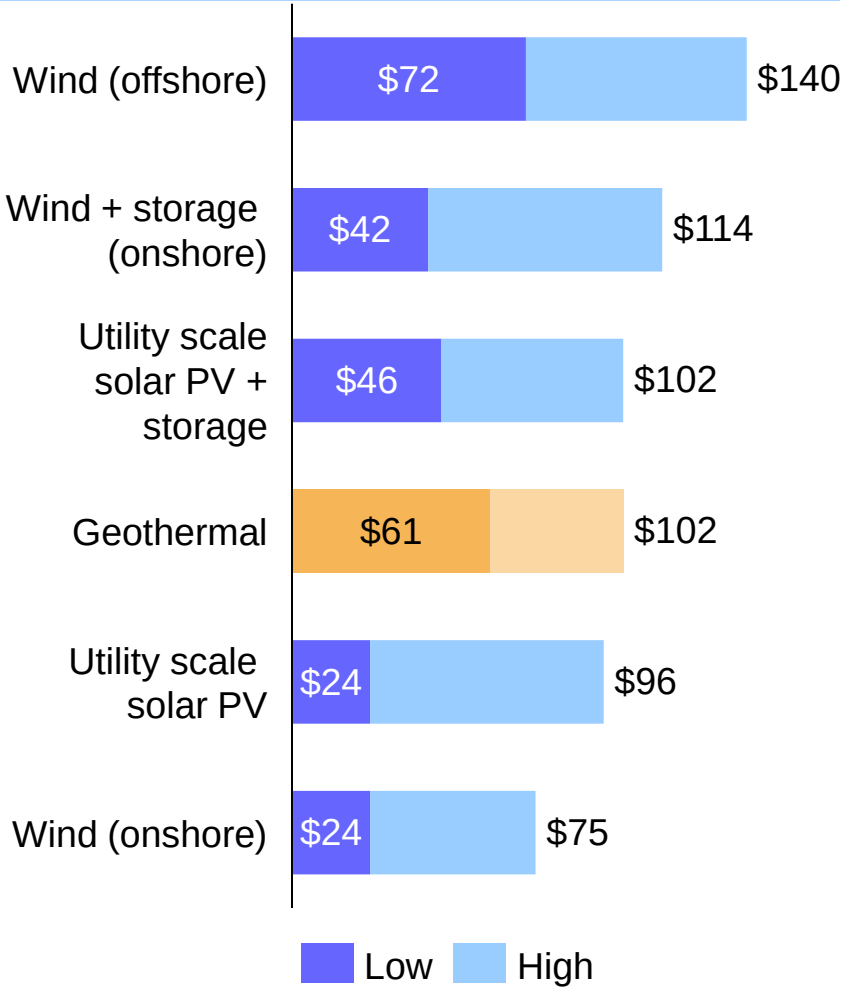
Technology overview

- Conventional geothermal is cost-competitive with renewable technologies …
- …However, conventional geothermal is limited in where it can be developed
- Geothermal systems require three ingredients:



- New geothermal technologies are being developed to expand geothermal to areas where one or more of these ingredients are missing
- Dozens of new start-ups are entering this space to advance these technologies

Levelized cost of energy for renewable energy ($/MWh)



There are four key types of geothermal energy technology

Key types of geothermal energy technologies

1 Conventional geothermal

- Mature technology behind all commercial geothermal capacity in place today
- Requires all three geothermal ingredients: heat, fluid, and permeability
- Limited in deployment due to siting challenges

2 Enhanced geothermal systems (EGS)

- Next-generation geothermal technology that can be deployed in without permeability or fluid
- Currently estimated to cost ~$450 per MWh
- Recent U.S. Department of Energy “Earthshot” program has goal of cutting cost by 90%

3 Advanced geothermal systems (AGS)

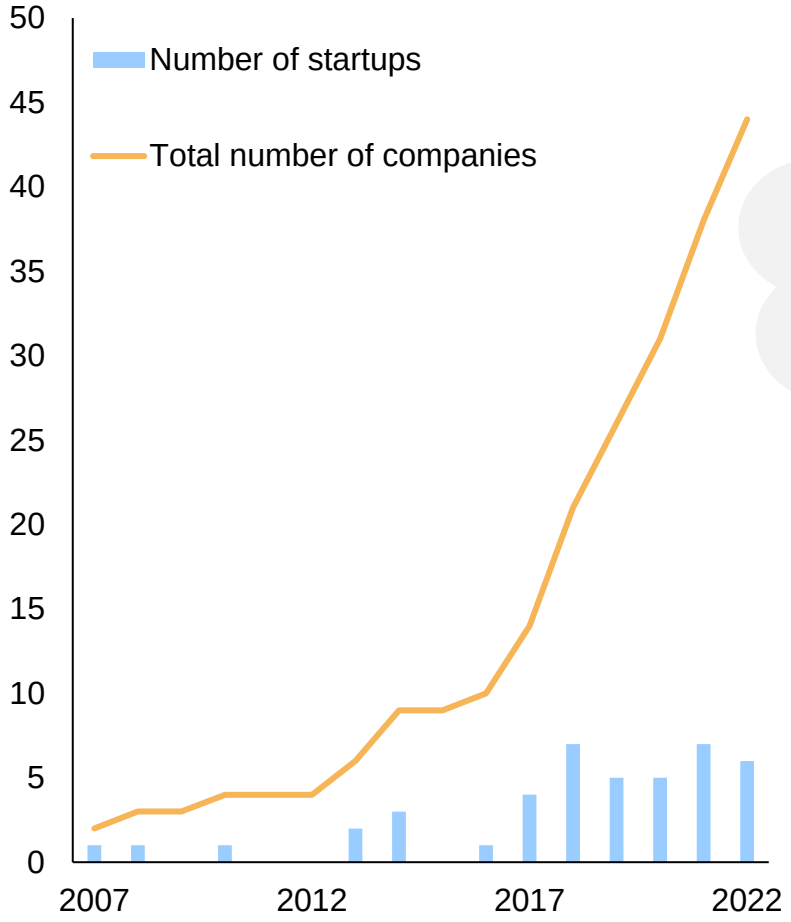
- Systems have been around for years
- Next-generation systems are revamping with oil and gas technologies
- No fluids are introduced or extracted; rather fluid is circulated in sealed pipe and boreholes to pick up heat by conduction

4 Supercritical geothermal

- “Holy grail” of geothermal with significant engineering challenges
- Requires water above 373 °C and 220 bar pressure, where it becomes supercritical
- At this supercritical state, more energy is produced from a well and more electricity from that energy

Several new start-ups have emerged along with new public funding and …

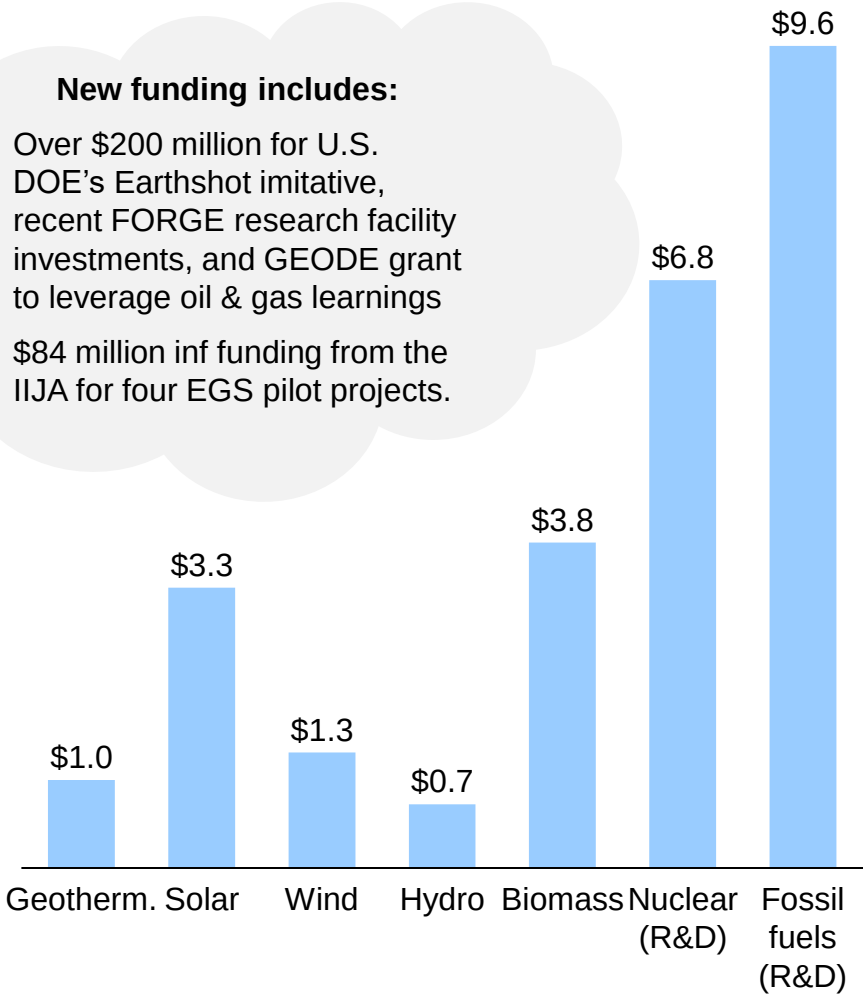
Development of geothermal companies
(Number of companies)



U.S. DOE funding 2004-2019
(USD, billion)

New funding includes:

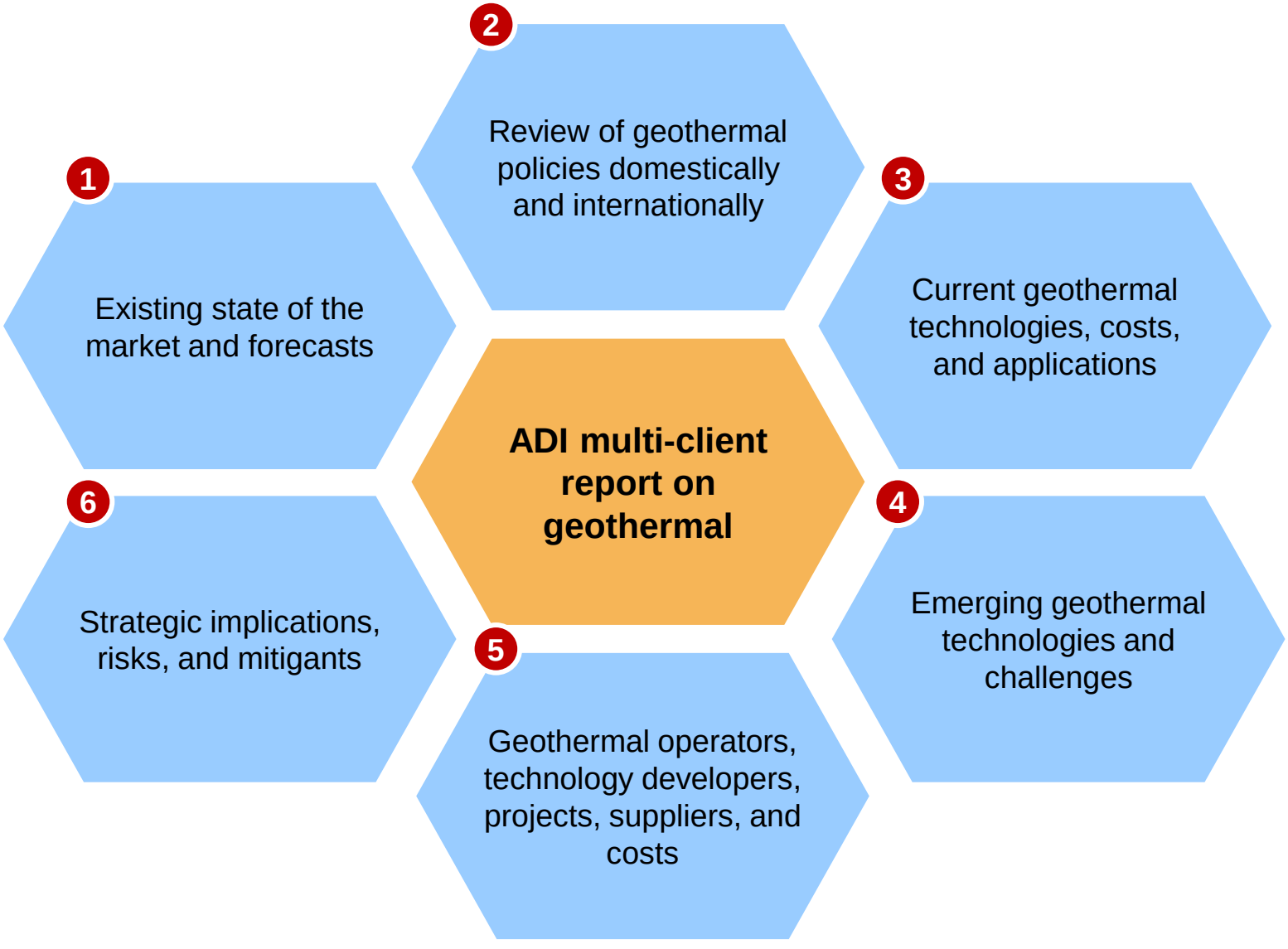
- Over $200 million for U.S. DOE's Earthshot imitative, recent FORGE research facility investments, and GEODE grant to leverage oil & gas learnings
- $84 million inf funding from the IIJA for four EGS pilot projects.



… The industry is seeing investments from the private sector, largely by oil and gas companies

Geothermal company	Private investor	Discussion
FERVO ENERGY	devon	Devon has invested $10 million in venture funding
BASELOAD CAPITAL	Chevron	Established a joint venture to develop geothermal projects in the U.S.
Eavor	Chevron, bp	Chevron and BP have invested $40 million venture funding
Kitselas Geothermal		Partnering for a geothermal study in Canada
CONTROLLED THERMAL RESOURCES	gm	GM has made a ‘multimillion-dollar investment’ to develop CTR’s Hell’s Kitchen geothermal lithium project
ENERGYSOURCE MINERALS	Ford	Ford signed lithium supply contract with ESM for geothermal lithium from their Project ATLiS

The ADI study will be an in-depth review of geothermal drivers, technologies, costs, incentives, innovation, projects, and players



ADI's expertise and experience in geothermal includes serving U.S. DOE on EGS costs, economics, and analytics since 2010

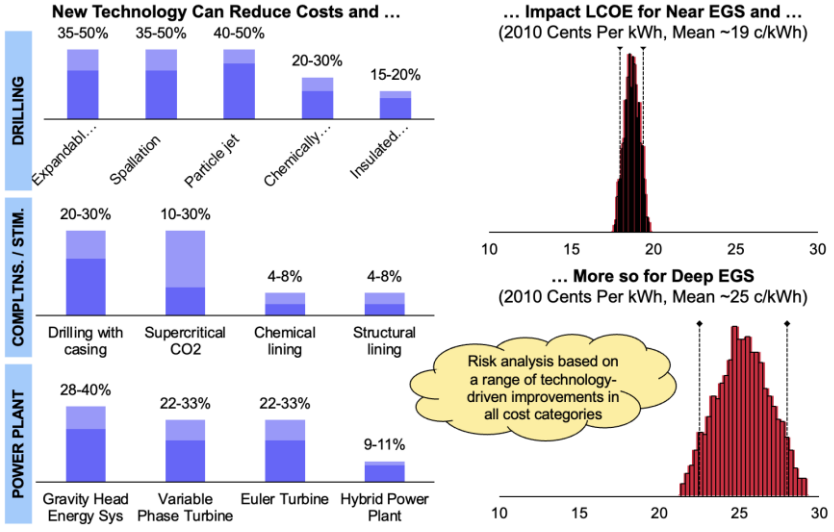
ADI's geothermal experience

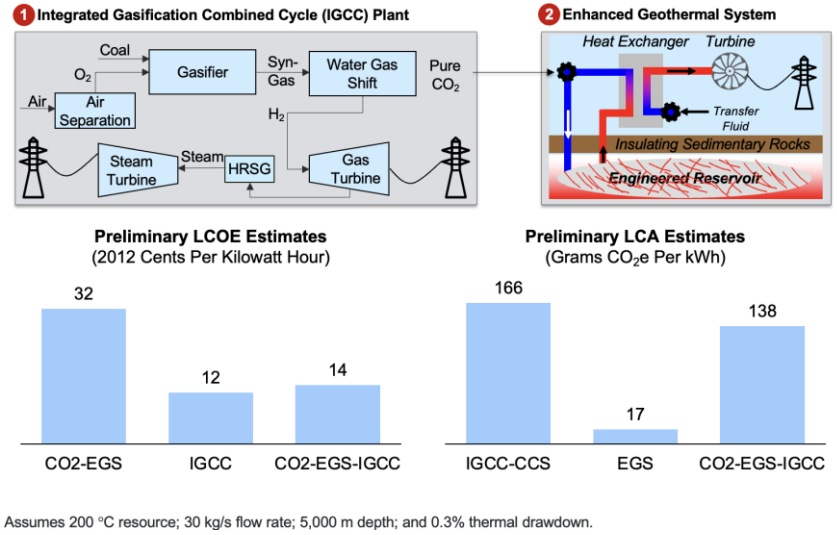
- ADI led a 3-year, U.S. DOE-funded study on costs and economics of geothermal energy …
- … Exploring how oil & gas technologies and practices can cut costs of EGS in particular
- Advised many start-ups, oil & gas majors, oilfield service players, renewable power developers, and investors on geothermal

ADI publications on geothermal

- Four proprietary reports on costs, learning rates, patent analytics, and new configurations
- Spoke at leading geothermal events, e.g., GRC, GSPAWG, DOE Peer Review, ICCS&T
- Published ~10 peer-reviewed articles and conference presentations on various aspects of geothermal energy costs and technology

Examples of ADI's geothermal research for U.S. Department of Energy





Assumes 200 °C resource; 30 kg/s flow rate; 5,000 m depth; and 0.3% thermal drawdown.

Source: ADI reports to U.S. Department of Energy, see https://adi-analytics.com/store/ for more info

The proposed study's table of contents is detailed and comprehensive and can be shaped and refined by subscribers

1	**Executive summary** *Key conclusions, findings, and strategic implications with a review workshop and data pack*	7	**Challenges for geothermal** *Analysis of challenges including in technical advances and implementation*
2	**Introduction to geothermal** *Background and introductory information on existing geothermal technology and projects*	8	**Geothermal projects in progress** *Details on geothermal projects and review of companies operating in this space*
3	**Geothermal market and forecasts** *Review of geothermal projects, investors, and forecasts and drivers for growth*	9	**Geothermal costs and economics** *Breakdown of costs and economics for geothermal technology and facilities*
4	**U.S. policies and incentives** *Review of local and federal policies and regulations promoting and financing geothermal*	10	**Risks and mitigants** *Review of risks for geothermal implementation and mitigants available*
5	**Global policies and incentives** *Review of international policies and regulations promoting and financing geothermal*	11	**Market and strategic implications** *Analysis of implications for various technical, structural, and regulatory changes for geothermal*
6	**Innovations in geothermal** *Analysis of emerging technologies, innovations and players in this space*	12	**Conclusions and recommendations** *Key findings and major conclusions*

ADI's "The Future of Geothermal" study offers subscribers a number of benefits

Outcomes	Deliverables
1 In-depth coverage of geothemal space	~100-page report
2 Extensive review of existing and emerging global policy and initiatives	~20-page executive summary deck
3 Review of projects, technology, players, and stakeholders	Spreadsheet data package
4 Geothermal costs and breakdown by technology type and cost improvement opportunities	Review workshop
5 Key commercial insights and strategic implications	Analyst access

Contact Uday Turaga, +1.281.506.8234 or info@adi-analytics.com to purchase this study.

Outline

- Study Prospectus
- **About ADI**

ADI is a consulting firm serving oil & gas, energy, chemicals, and industrial clients with expertise, rigor, and passion

Operators | **Investors** | **Industrials** | **Traders** | **Government**


Oil


Gas & LNG


Midstream & NGLs


Refining


Fuels


Feedstocks


Petrochemicals


Basic Chemicals


Polymers & Plastics


Specialty Chemicals


Power generation


Renewables


Transmission


Energy Transition


Transportation

Markets | **Operations** | **Technology** | **Commercial** | **Policy**

Over 300 clients - Fortune 500 brands, mid-sized firms, start-ups, and investors have engaged ADI to shape decisions

Our value proposition – expertise, experience, analytics, and thought leadership – is designed to help clients succeed

Deep, frontline **industry expertise**

Over **600 projects** for **300+ clients** since 2009

Differentiated **thought leadership**

Proprietary analytics- and **data-driven**

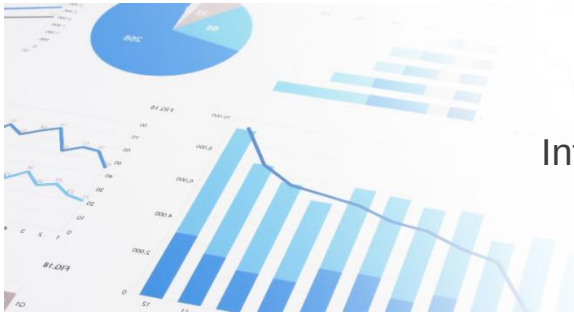
Clients accelerate priorities with ADI's consulting services, subscription research, data analytics, and conferences

Consulting

Discover and capture opportunities, solve problems, and help businesses thrive amid uncertainty with ADI's market research and management consulting services

Research

Track markets with ADI's subscription research



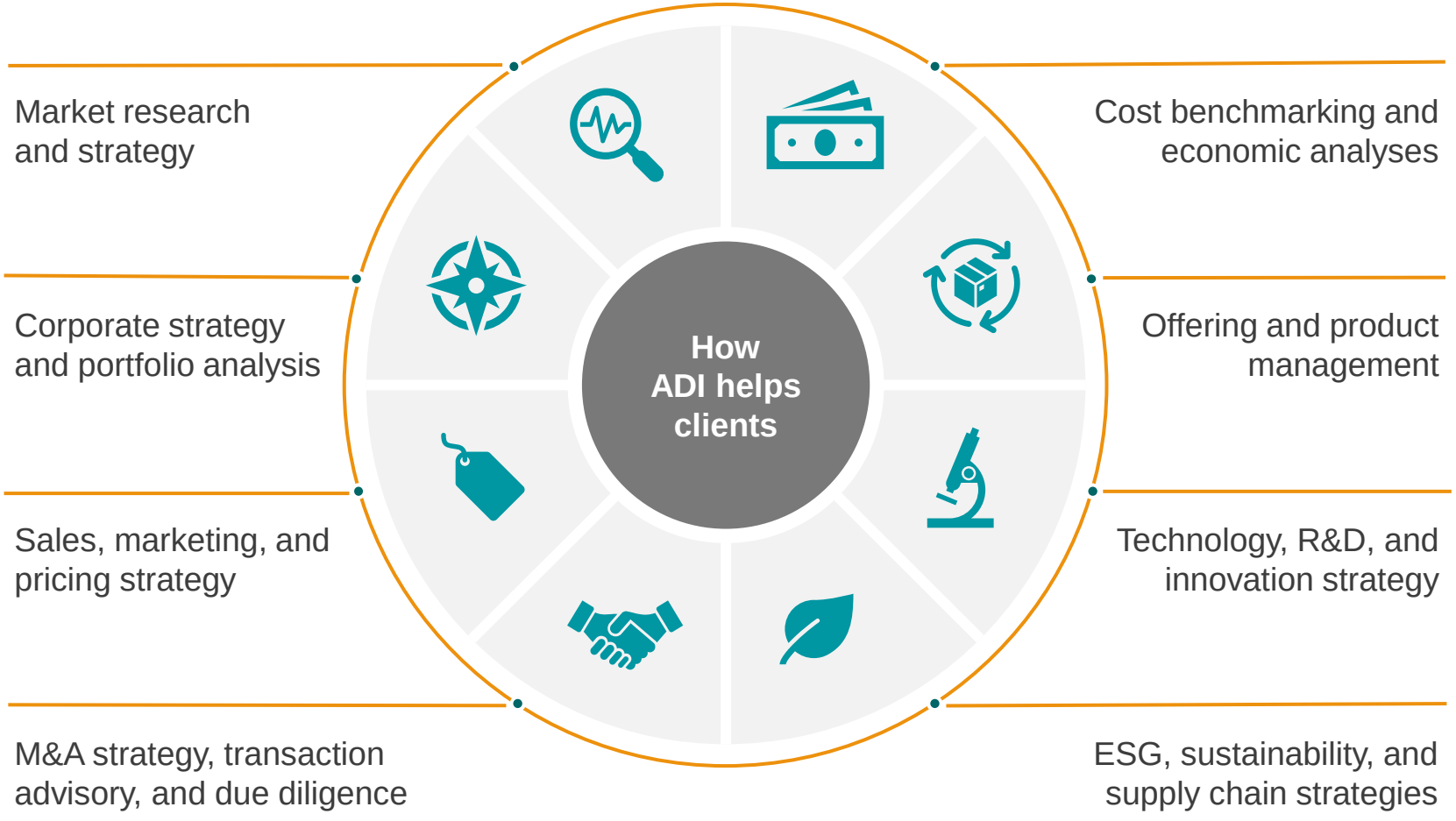
Analytics

Inform workflows with ADI data, models, and analytics

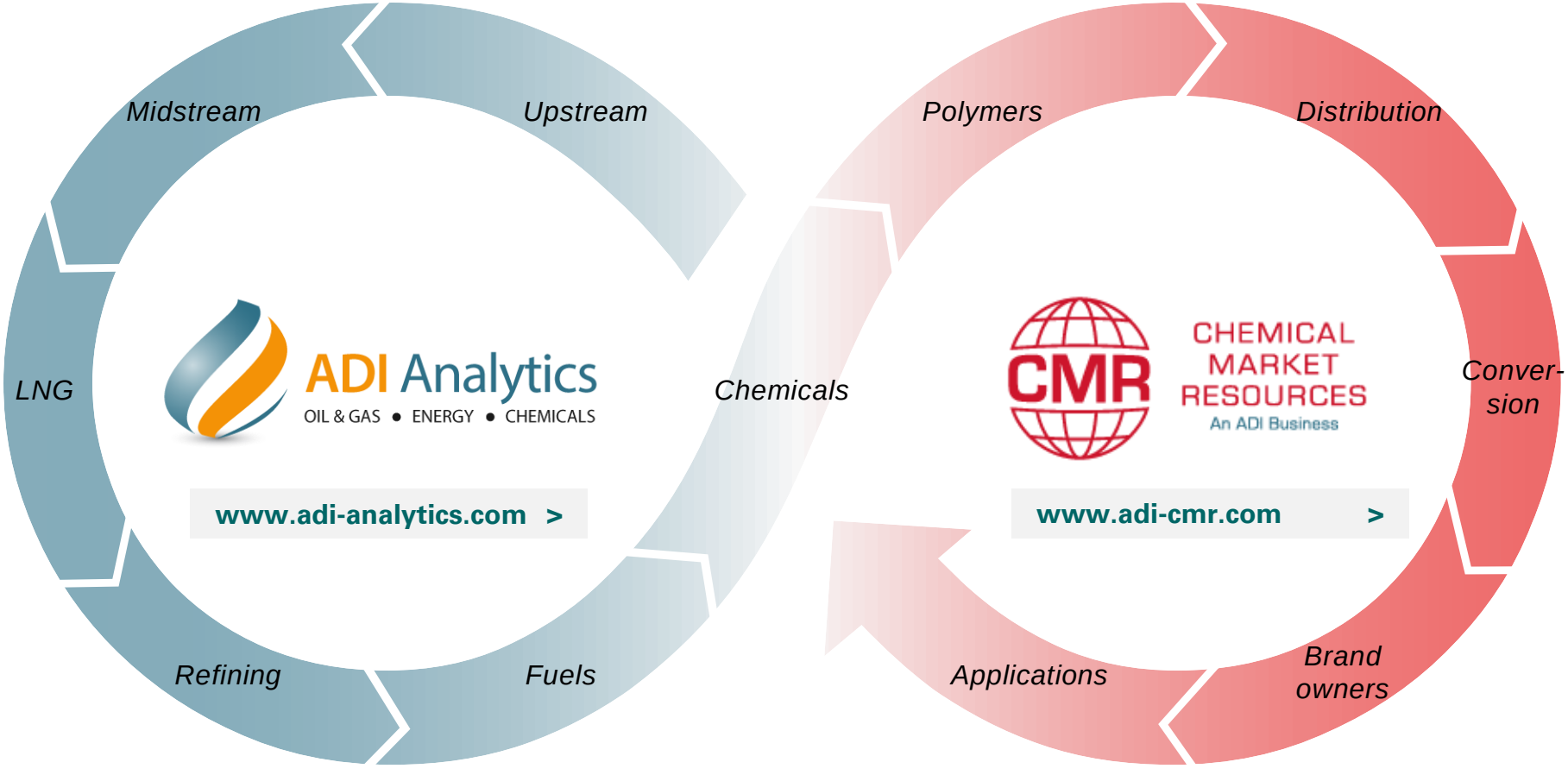
Forum

Build a strategic view and network at our conference

Clients shape strategy, grow sales, refine costs, drive deals, and build competencies with ADI's consulting services



After acquiring Chemical Market Resources, ADI's expertise has grown and now spans the entire hydrocarbon value chain



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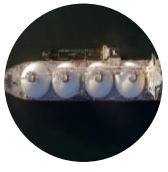
Sustainable aviation fuel (SAF)

Alternative marine fuels market study

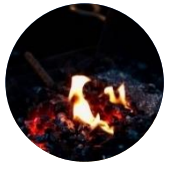


Global / NA small-scale LNG

U.S. gasoline and octane outlook

Assessing opportunities in bio-based chemicals

Benchmarking shale gas monetization options



Critical minerals and energy transition

Access research and reports >>

ADI enjoys a stellar reputation for exceptional project delivery and client service and satisfaction

"Work directly with firm partners … high-quality work products."

– Alex Rozenfeld, *VP, Ventures, Shell*

"The best about ADI is their ability to drill into a specialized area."

– Johanna Schmidtke, *Director, Saudi Aramco*

"They've been outstanding. ADI is very thorough, very professional. They deliver a lot of good insights right out of the gate."

– Randy Benson, *VP, Sales, Harsco*

"ADI did a great job to help us think and advance in making our investments."

– Meghan Leggett, *Principal, White Deer*

"Lots of oil & gas expertise. Very analytically driven. Better customer service."

– Vikki Dunn, *CMO, GE Oil & Gas*

"Very diligent, very detailed … went the extra mile."

– Elliott Smith, *VP, Strategy, Voith*

"The thoroughness of ADI's research is phenomenal."

– Steve Woodward, *SVP, Antero Resources*

"ADI has very deep market knowledge and access to the right experts and delivered very successful projects."

- Brian Orkin, *Partner, Arsenal Capital Partners*

Build a strategic view of O&G, energy transition and chemical industries informed with executive perspectives at ADI Forum

Oil & Gas

Upstream, midstream, natural gas, LNG, refining, and fuels

Energy Transition

Renewable power, CCUS, biofuels, hydrogen, batteries, and sustainability

Chemicals

ADI Forum now covers chemicals and plastics replacing our FlexPO+ event

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