America’s renewable powered transformation

Matt DaPrato | October 2019
About Wood Mackenzie

We provide commercial insight and access to our experts leveraging our integrated proprietary metals, energy and renewables research platform.

Wood Mackenzie is ideally positioned to support consumers, producers and financers of the new energy economy.

- Acquisition of MAKE and Greentech Media (GTM)
- Leaders in renewables, EV demand and grid-connected storage
- Over 500 sector-dedicated analysts and consultants globally, including 80+ specifically to power and renewables
- Located close to clients and industry contacts
Market evolutions and technology revolutions have disrupted legacy business models, creating a new energy landscape.

The Power Market of the Past
A top-down flow from supply to demand

Tomorrow’s Decarbonized and Decentralized Power Market
A bidirectional energy network with new technologies and actors at every node reshaping power market planning and operations.
Renewable energy dominant power systems will force changes across the power industry

- Cost competitive renewables accelerate ambitious policy and will alter power market design
- The rapid pace of technology change is altering both what and how utilities procure power
- New customer demands and competitor offerings are shaping the ‘utility of the future’
The end of the beginning: Renewables are cheap
Wind and solar competitive as subsidies sunset

Cost effective storage and deployment innovation bring new threats to natural gas generation

US LCOE (US$ real) outlook by technology and carbon scenario

Note: * Average represents unweighted average of all states
Cheap renewables are accelerating aggressive policy
The United State’s could add three California’s without federal support

Policy is taking shapes in nearly all region’s of the country

Source: Wood Mackenzie
The policy divide shapes the post-2030 gas opportunity
Solar’s rise to ~20% penetration defines next phase of decarbonization

Aging nuclear stunts PJM and MISO ZC growth, while offshore wind drives the Northeast

Zero-carbon penetration by ISO to 2040

Note: Storage excluded, reflects generation only. Zero carbon includes DG solar
Source: Wood Mackenzie
Power market design will change
Energy prices will likely be insufficient to support higher penetrations of wind and solar

Capacity and REC markets represent potential available existing sources but duration and competition uncertainty create ‘bankability’ risk and greater state involvement in procurement

Hourly renewables penetration and power price impact: 2018

Source: Wood Mackenzie, ISOs
Competitive renewables are changing power procurement strategies
Arizona Public Service highlights how change continues to outpace even ‘aggressive’ views

### 2017 Selected Plan
507 MW by 2032

### 2017 Storage Case
1,107 MW by 2032

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**Resource Contributions (2032 Nameplate Capacity/% Energy Mix)**

<table>
<thead>
<tr>
<th>Resource Type</th>
<th>Capacity (MW)</th>
<th>% Nuclear</th>
<th>% Coal</th>
<th>% Natural Gas</th>
<th>% Renewable Energy (RE &amp; OR)</th>
<th>% Demand Side Management</th>
<th>% Demand Response &amp; Microgrids</th>
<th>% Energy Storage**</th>
<th>% Market Purchase</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Nuclear</strong></td>
<td>1,146 MW / 17.1%</td>
<td>1,146 MW / 17.1%</td>
<td>1,146 MW / 17.0%</td>
<td>1,146 MW / 16.9%</td>
<td>1,146 MW / 17.0%</td>
<td>1,146 MW / 16.7%</td>
<td>1,146 MW / 16.7%</td>
<td>1,146 MW / 16.7%</td>
<td>1,146 MW / 22.3%</td>
</tr>
<tr>
<td><strong>Coal</strong></td>
<td>970 MW / 10.7%</td>
<td>0 MW / 0.0%</td>
<td>970 MW / 10.5%</td>
<td>970 MW / 10.5%</td>
<td>970 MW / 10.5%</td>
<td>970 MW / 10.3%</td>
<td>970 MW / 10.3%</td>
<td>970 MW / 10.4%</td>
<td>970 MW / 10.4%</td>
</tr>
<tr>
<td><strong>Natural Gas</strong></td>
<td>8,475 MW / 32.9%</td>
<td>9,616 MW / 42.8%</td>
<td>7,828 MW / 27.4%</td>
<td>8,259 MW / 30.4%</td>
<td>8,259 MW / 30.4%</td>
<td>7,181 MW / 26.4%</td>
<td>7,181 MW / 26.4%</td>
<td>7,181 MW / 26.4%</td>
<td>8,043 MW / 28.8%</td>
</tr>
<tr>
<td><strong>Renewable Energy (RE &amp; OR)</strong></td>
<td>4,353 MW / 18.2%</td>
<td>4,353 MW / 18.3%</td>
<td>4,353 MW / 18.3%</td>
<td>5,052 MW / 21.7%</td>
<td>4,353 MW / 18.1%</td>
<td>4,697 MW / 19.6%</td>
<td>4,353 MW / 19.8%</td>
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</tr>
<tr>
<td><strong>Demand Side Management</strong></td>
<td>922 MW / 13.4%</td>
<td>922 MW / 13.5%</td>
<td>1,547 MW / 20.8%</td>
<td>922 MW / 13.4%</td>
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<td>1,547 MW / 20.5%</td>
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</tr>
<tr>
<td><strong>Demand Response &amp; Microgrids</strong></td>
<td>420 MW</td>
<td>420 MW</td>
<td>420 MW</td>
<td>420 MW</td>
<td>420 MW</td>
<td>420 MW</td>
<td>420 MW</td>
<td>420 MW</td>
<td>420 MW</td>
</tr>
<tr>
<td><strong>Energy Storage</strong></td>
<td>507 MW</td>
<td>507 MW</td>
<td>507 MW</td>
<td>507 MW</td>
<td>507 MW</td>
<td>1,107 MW</td>
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<td>507 MW</td>
</tr>
<tr>
<td><strong>Market Purchase</strong></td>
<td>158 MW / 7.7%</td>
<td>158 MW / 8.5%</td>
<td>158 MW / 6.5%</td>
<td>158 MW / 7.9%</td>
<td>158 MW / 7.9%</td>
<td>158 MW / 6.7%</td>
<td>158 MW / 6.7%</td>
<td>158 MW / 6.5%</td>
<td>158 MW / 6.8%</td>
</tr>
</tbody>
</table>

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*OR and microgrids are considered capacity resources and are not included in the energy mix.

**Energy storage does not create its own energy, so energy associated with it is reported under the source that provided the charging energy.

Source: Arizona Public Service – 2017 Resource Plan
Arizona Public Service highlights how change continues to outpace even ‘aggressive’ views

February 2019 Action
850 MW by 2025
150 MW comes from 2018 ‘peaking’ RFP
7 year PPA for existing gas peaker

<table>
<thead>
<tr>
<th>Resource Categories</th>
<th>Description</th>
<th>Nuclear</th>
<th>Coal</th>
<th>Natural Gas</th>
<th>Renewable Energy (RE &amp; DE)</th>
<th>Demand Side Management</th>
<th>Demand Response &amp; Microgrids*</th>
<th>Energy Storage**</th>
<th>Market Purchase</th>
</tr>
</thead>
<tbody>
<tr>
<td>FLEXIBLE RESOURCE (2017 IRP SELECTED PLAN)</td>
<td>Retire Cholla in 2024; demand reducing DSM; RE above compliance, flexible battery storage &amp; gas generation</td>
<td>1,146 MW / 17.1%</td>
<td>0 MW / 0.1%</td>
<td>8.475 MW / 12.3%</td>
<td>4,333 MW / 18.2%</td>
<td>922 MW / 13.4%</td>
<td>420 MW</td>
<td>507 MW</td>
<td>58 MW</td>
</tr>
<tr>
<td></td>
<td>Retire Cholla in 2024; Four Corners in 2031; demand reducing DSM; RE above compliance, flexible battery storage &amp; gas generation</td>
<td>1,146 MW / 17.1%</td>
<td>970 MW / 15.1%</td>
<td>7,918 MW / 27.4%</td>
<td>4,333 MW / 18.2%</td>
<td>922 MW / 13.4%</td>
<td>420 MW</td>
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<td>58 MW</td>
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<td>Retire Cholla in 2024; energy reducing DSM; RE above compliance, flexible battery storage &amp; gas generation</td>
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<td>420 MW</td>
<td>507 MW</td>
<td>58 MW</td>
</tr>
<tr>
<td></td>
<td>Retire Cholla in 2024; plus expanded DSM; renewables and battery storage, gas generation</td>
<td>1,146 MW / 16.9%</td>
<td>970 MW / 15.1%</td>
<td>8,259 MW / 30.4%</td>
<td>4,333 MW / 18.2%</td>
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<td>507 MW</td>
<td>58 MW</td>
</tr>
<tr>
<td></td>
<td>Retire Cholla in 2024; SMR; demand reducing DSM; RE above compliance, flexible battery storage &amp; gas generation</td>
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<td>970 MW / 15.1%</td>
<td>8,259 MW / 30.4%</td>
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<td>58 MW</td>
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</tbody>
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Resource Contributions (2032 Nantitate Capacity/% Energy Mix)

- Nuclear: 1,146 MW / 17.1%
- Coal: 970 MW / 15.1%
- Natural Gas: 8.475 MW / 12.3%
- Renewable Energy (RE & DE): 4,333 MW / 18.2%
- Demand Side Management: 922 MW / 13.4%
- Demand Response & Microgrids*: 420 MW
- Energy Storage**: 507 MW
- Market Purchase: 158 MW / 2.5%

*DR and microgrids are considered capacity resources and are not included in the energy mix.
**Energy storage does not create its own energy, so energy associated with it is reported under the source that provided the charging energy.

Source: Arizona Public Service – 2017 Resource Plan
Corporate RE targets a growth driver for IPPs and utilities
Competition for 85 GW of F1000 demand alters utility & IPP competition and injects new project risks

As virtual PPAs grow among C&I buyers, utilities fearing ratebase erosion respond with competitive green tariff programs, +100% since 2016

<table>
<thead>
<tr>
<th>Offtaker</th>
<th>GW under contract</th>
<th># of PPAs</th>
<th>% of market share (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facebook</td>
<td>2.2</td>
<td>24</td>
<td>14.1%</td>
</tr>
<tr>
<td>Google</td>
<td>2.1</td>
<td>15</td>
<td>13.7%</td>
</tr>
<tr>
<td>Amazon</td>
<td>1.1</td>
<td>14</td>
<td>7.3%</td>
</tr>
<tr>
<td>AT&amp;T</td>
<td>0.8</td>
<td>4</td>
<td>5.2%</td>
</tr>
<tr>
<td>Walmart</td>
<td>0.8</td>
<td>10</td>
<td>5.1%</td>
</tr>
<tr>
<td>Apple</td>
<td>0.8</td>
<td>7</td>
<td>5.0%</td>
</tr>
<tr>
<td>Microsoft</td>
<td>0.6</td>
<td>5</td>
<td>4.1%</td>
</tr>
<tr>
<td>Exxon Mobil</td>
<td>0.5</td>
<td>2</td>
<td>3.2%</td>
</tr>
<tr>
<td>Equinix</td>
<td>0.4</td>
<td>3</td>
<td>2.4%</td>
</tr>
<tr>
<td>Other</td>
<td>6.2</td>
<td>141</td>
<td>39.9%</td>
</tr>
</tbody>
</table>

Cumulative RE100 signatories by year

New C&I entrants by year, U.S.
Demand is a key supply strategy
Leaders look to ‘Grid Edge’ to deliver customer value, higher returns

Competitive players and regulated utilities seek to generate value by providing resiliency and flexibility to both the customer and wholesale market.
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