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The heterogenous role of energy policies in the energy transition of Asia-Pacific emerging economies

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Abstract: The achievement of sustainable energy systems requires well-designed energy policies, particularly targeted strategies to plan the direction of energy development, regulations monitored and executed through credible authorities, and laws enforced by the judicial system for the enhancement of actions and national targets. The Asia-Pacific region (APAC), responsible for more than half of global energy consumption, has enacted a large number of energy policies over the last two decades, but progress on the energy transition remains slow. This study focuses on the aggregate effect of energy policies on the progress towards sustainable targets in 42 emerging economies from 2000 to 2017. We find that energy policies have contributed to improving access to electricity (3.0%), access to clean cooking (3.8%), energy efficiency (1.4%) and renewable electricity capacity (6.9%), respectively. Among different types of energy policies (strategies, laws and regulations), strategies have greater impacts on advancing electrification, clean cooking and renewable electricity capacity than laws and regulations, whereas the laws are more effective for achieving energy efficiency.

Keywords: Energy transition; SDG7; Energy policy; Asia-Pacific region

Main

The transition from conventional energy consumption to clean and sustainable energy use is critical to sustainable development given that the energy sector contributes over 90% of CO₂ emissions worldwide¹. Achievable energy transition has been repeatedly advocated as the fundamental solution to the climate crisis in the context of United Nations climate change conferences including the Paris Agreement². The Asia-Pacific (APAC) region plays a crucial role in the global fight against climate change. It includes countries with diverse levels of economic development and geographical characteristics (ranging from continent countries to small islands). It is estimated that about half of all economic growth in the world will happen in the APAC region by 2050³, leading to 45% growth in electricity demand⁴. However, the energy transition is lagging in the region. The proportion of renewable energy in overall energy use has fallen from 22.7% in 2000 to 16% in 2019 while greenhouse gas (GHG) emissions have doubled, accounting for half of the world's emissions. Many countries in the APAC region are heavily dependent on conventional energy sources with unpredictable levels of energy poverty and volatility in energy prices⁵⁻⁷.

Against this complex backdrop, a systematic assessment of the measures introduced so far in the APAC region to facilitate the energy transition can provide critical information to support policymakers⁸. To accelerate the energy transition, governments ensure that policies cover a broad set of industries, economic sectors and administrative units with various objectives⁹⁻¹². Governments' commitment and effective implementation of policies are fundamental to make progress with the energy transition^{13,14}. In particular, to achieve global pollution emissions reduction, energy transition and sustainable development, there is a strong need for integrated policy efforts¹⁵⁻¹⁷. However, previous

43 studies have mostly focused on analysing the energy transition of countries in the Organization for Economic
44 Cooperation and Development (OECD) or the developed economies rather than the Global South^{2,18,19}. Studies have
45 considered policy mixes to achieve energy transition as interactions between policy implementation and energy
46 system operations^{20,21}. The pros and cons of combinations of energy policies and their impacts have also been
47 discussed^{20,22,23}. Research has also analysed the institutional context of policy implementation to gain insights into
48 the formulation of policy mixes for energy transition²⁴. To support sustainable and inclusive development in the
49 APAC region, understanding the impacts of energy policies on progress toward energy transition is critical to design
50 effective policies.

51 Progress on energy transition is currently assessed primarily through Sustainable Development Goal 7 (SDG7)
52 – ensuring access to affordable, reliable, sustainable and modern energy for all – that contains energy access and
53 renewable energy use as an alternative indicator for energy transition^{7,25}. So far, SDG7 targets have been used to
54 assess the progress of energy transition under the Paris Agreement^{26–28}, and the performance of SDG7 in the APAC
55 region is documented by United Nations²⁹. In addition, energy policies in the APAC region have grown remarkably
56 over the last two decades, particularly in relation to the promotion of electrification and renewable energy capacity³⁰.
57 However, there are substantial differences in the institutional, economic and resource endowments of countries in the
58 APAC region, and there is considerable uncertainty in the development of their policy frameworks and regulatory
59 environments, as well as notable disparities in the stages of energy transition across countries, especially in the case
60 of emerging economies^{15,31}. It is therefore challenging to measure the relationship between energy policy and energy
61 transition from a regional perspective because of the lack of a quantitative research framework.

62 To bridge this research gap, in this study we apply statistical methods to evaluate the impact of energy policies
63 on the progress towards energy transition in the APAC region. We present a framework for the quantitative assessment
64 of the aggregate effect of energy policies on energy transition. Here, we first track progress towards the achievement
65 of the SDG7 targets within the APAC region through the SDG7 indicators. Then we collect the energy policies by
66 using the *Asia Pacific Energy Portal Policy* database, which covers 42 emerging economies and 2112 energy policies
67 over the period 2000-2017 (Supplementary Table 1-2, Supplementary Figure 1). Finally, we estimate the relations
68 between the adoption of energy policies and the realization of the energy transition using panel data regression models,
69 and further quantify the contribution of each policy type. The results offer an overview of the energy policies in the
70 APAC region and their impacts on energy transition.

71

72 **Energy transition progress in the APAC region**

73 The 42 APAC economies are classified into three groups based on economic fundamentals released by the
74 United Nations³², which are least developed countries (LDCs), developing countries and economies in transition.
75 Economies in transition refer to the Commonwealth of the Independent States, most of which are vulnerable to
76 uncertainty and external shocks³². In the APAC region, progress toward energy transition has not been uniform over
77 the period 2000-2017 (Fig. 1). Access to electricity (indicator 7.1.1) is well achieved, with a median value of the
78 progress of 0.977 in 2017. It is followed by the access to clean cooking (indicator 7.1.2), for which about half of the
79 economies in the region met the targets and the median value in 2017 is 0.48. Regarding the energy intensity level of
80 primary energy (indicator 7.3.1), most of the countries are halfway to achieving their targets, thus requiring
81 substantial improvement. For renewable electricity capacity (indicator 7.b.1), only one-fifth of the countries or
82 regions have reached their targets.

83 Fig 1 shows the specific characteristics of the various stages of the energy transition in the different groups of
84 countries. Electrification, as a priority target, is achievable across all countries. Economies in transition are
85 progressing more toward electrification, clean cooking, and renewable electricity capacity, but less toward energy
86 efficiency. LDCs have made notable progress in electrification and energy intensity targets, but they need to

87 strengthen access to clean cooking. Developing economies do not stand out in terms of progress toward energy
88 intensity and renewable electricity capacity targets. On the one hand, progress depends heavily on geographical
89 location, local resources and infrastructures. On the other hand, it is significantly correlated to the level of economic
90 development. In LDCs the primary aim is eliminating energy poverty and improving energy access, whereas
91 industrialized countries promote renewable energy and clean cooking for a higher living standard.

92 Specifically, the highest success in the region has been achieved in terms of access to electricity. In 2017, 95%
93 of the total population in the APAC region have access to electricity, growing from 87% in 2010 when 14 out of 42
94 economies have 100% access. Economies in transition and developing countries show higher levels of electrification
95 on the whole, while LDCs are characterized by faster growth of electrification. Notably, since the government in
96 Afghanistan pushed renewable energy adoption and focused on rural electrification through off-grid deployment,
97 electrification increased from 23% (only 8% in rural areas) in 2005 to 97.7% (97.1% in rural areas) in 2017. In
98 contrast, access to clean cooking has not progressed well. Energy consumption for cooking in least developed
99 countries is still in part dependent on fuelwood, charcoal and solid biofuels, e.g. crop residues and dung, such as in
100 the case of Bhutan (whose solid biofuels account for about three-quarters of energy consumption). Furthermore, the
101 shift away from conventional biofuel sources does not ensure the adoption of cleaner energy sources, but rather the
102 use of fuels such as liquefied petroleum gas⁴. Such a pattern seems undesirable but it might be the only way towards
103 the energy transition for the LDCs and some small islands, where clean cooking has grown slowly starting from a
104 low level.

105 Progress in terms of energy intensity is also limited, with the indicator falling well short of the target value.
106 There is a low correlation between the target and the level of economic development, and economies in transition
107 have generally achieved limited progress in terms of energy intensity. This is because reducing energy intensity takes
108 place relatively late in the energy transition¹⁸, with access to electricity and clean cooking being the main targets of
109 the current transition in APAC³³. The policy framework for energy efficiency in emerging countries is currently weak,
110 and only a few economies have relatively mature energy efficiency policies and regulatory environments³⁴. In
111 addition, renewable electricity capacity is the least developed overall, and energy sources vary by income levels in
112 the APAC region. Low-income countries rely on solid biofuels mostly (accounting for 88%), while the contribution
113 of solar and wind energy is gradually increasing in the better-off economies (Supplementary Figure 2). Recently, the
114 installation costs of solar and wind have dropped substantially and have nearly achieved grid parity compared to
115 fossil fuels³⁵. The installations of solar and wind energy have grown from only 396 MW and 1482 MW in 2000, to
116 about 216 GW and 217 GW in 2017, with their average annual growth rates being 45% and 34% respectively
117 (Supplementary Figure 3).

118 119 **The aggregate effect of energy policies on energy transition**

120 We estimate progress toward energy transition in the APAC in absence of any energy policy (counterfactual
121 progress) and compare it to observed progress, under existing energy policies (Table 1). We calculate the aggregate
122 effect of energy policies on progress toward energy transition (Fig. 2). The shaded area between observed progress
123 (solid line) and counterfactual progress (dashed line) represents the aggregate effect of energy policies. The figure
124 shows that energy policies started to affect the energy transition from 2000. According to Fig. 2, energy policies
125 contribute to progress toward energy transition by 3.0% in terms of access to electricity, 3.8% in terms of access to
126 clean cooking, 1.4% in terms of energy intensity reduction and 6.9% in terms of renewable electricity capacity, on
127 average over the study period.

128 In addition, we disaggregate the counterfactual progress of each target by individual country in each category
129 (Fig. 3). We find that overall energy transition is progressing faster in developing economies than in the other two
130 groups because these countries have more energy policies in place and are better positioned to promote, monitor and

131 safeguard their implementation. For example, India and Vietnam have issued 232 and 200 policies, followed by the
132 Philippines and Thailand with 193 and 101 policies respectively. The aforementioned countries are ranked top among
133 the 42 economies in the Asia Pacific region and showed the fastest progress toward energy transition. For example,
134 in South-East Asia, countries are set to achieve a 23% share of renewable energy in the primary energy supply by
135 2025. The governments have therefore adopted proactive measures, such as removal of fossil fuel subsidies,
136 consolidation of regional markets and acceleration of existing projects^{12,36,37}. Some countries have also set other
137 targets. The Philippines aims to reduce its energy intensity by 40% by 2030, and to this end, it has developed many
138 strategies including the use of energy efficiency codes, efficiency standards and equipment labelling^{12,38}. To
139 accelerate the adoption of renewables, Thailand has established an electric vehicle manufacturing industry by
140 providing tax incentives through fiscal policy¹². Our estimations include the impacts of all these policies.

141

142 **Effect of policy type on energy transition**

143 Policies may differ greatly in terms of their requirements, implementation and governance³⁹. Energy policies
144 adopted by APAC countries are of different types. We codify policy documents into categories such as laws (397 in
145 total), regulations (221 in total), strategies (353 in total), and others (1159 in total). Here law means legal requirements
146 established by legislation and enforced by the judicial system in line with national targets, while regulation refers to
147 the promulgation of targeted rules by executive power which are accompanied by extra-legal mechanisms for
148 monitoring, enforcement, and sanctioning of rule breakers⁴⁰. And strategy provides overall energy development
149 direction and strategic goals, including often a plan for the next few years.

150 We focus on the effect of the targeted policies in the form of law, regulation, and strategy on energy transition
151 (Supplementary Table 8). Overall, law, regulation and strategy policies all have positive effects on the energy
152 transition. Strategies play a relatively more important role than laws and regulations, which is consistent with
153 previous studies⁴¹. In Vietnam, for example, long-term strategies are preferred to other policies and play an important
154 role in facilitating energy transition. Over the past decades, Vietnam has introduced a number of mid- and long-term
155 development strategies, including the development of fossil fuels, electricity and renewable energy⁴². Among them,
156 the Renewable Energy Development Strategy to 2030 with outlook to 2050, aims to achieve an increase of power
157 generation capacity of 12.5% by 2025 (excluding large hydro) and of 21% by 2030, in addition to developing
158 pathways for various non-fossil fuel resources. At present, Vietnam's renewable energy capacity has already far
159 exceeded the 2020 target stated in its strategic plan.

160 We also quantify the effects of different types of energy policies in each country (Fig. 4) by estimating the
161 counterfactual effect of energy policies based on the regression results. Five economies representative of different
162 economic development levels are selected: Myanmar (least developed country), Kazakhstan (transition country), and
163 Vietnam, India and Fiji, which are developing countries located in different geographical areas in APAC.

164 Vietnam, as an emerging economy, shows a better energy transition performance than India, although the
165 impacts of different types of policies are similar in both countries, with laws and strategies prominent and favouring
166 especially access to electricity and clean cooking. In contrast, regulations play a role in India, while Vietnam relies
167 more on laws and strategies. On the one hand, this is due to India's federal structure, which gives a more prominent
168 role to regulations and supervision, although to a limited nature compared to countries like the US; on the other hand,
169 the energy transition framework relies heavily on strategy and law in its early years and gradually developed to
170 regulation. Fiji, an island nation in the Pacific, also relies heavily on laws and strategies to advance the energy
171 transition. Laws are confirmed particularly positive to improve access to electricity and clean cooking, and strategies
172 contribute significantly to enhancing energy efficiency. Myanmar is a country in South-East Asia and is one of the
173 poorest countries in the world. Myanmar has been dominated by agricultural production and has made little progress
174 in its energy transition, but results show that the implementing strategies has brought benefits, whereas the same is

175 not true of laws and regulations, which is also in line with the previous research⁴³. Regarding energy intensity
176 reduction, laws are critical because early-stage promotion of energy efficiency needs especially strong and legislative
177 support rather than a market push, particularly in the least developed areas. Kazakhstan is the largest country in
178 Central Asia with an energy transition focused on the development of renewable energy and a related legal and
179 regulatory framework that has developed over time⁴⁴. In 2009, Kazakhstan adopted a law On Supporting the Use of
180 Renewable Energy Sources, and the concept of transitioning to a green economy by 2050, a long-term strategy aimed
181 at vigorous development of renewable energy sources, but early policy results have been less than impressive.
182 Kazakhstan has since capitalised on the Belt and Road initiative to further promote clean energy projects, and its
183 strategy has proved effective in terms of electrification, access to clean cooking and renewable electricity capacity.
184 However, Kazakhstan has been slow to make progress in reducing its energy intensity, as much of the energy
185 infrastructure was built during the former Soviet era and is badly aged and not very energy efficient, which is the
186 focus of legislation and regulation in the next generation.

187 For the emerging economies in APAC region, the energy transition is not yet mature enough, therefore the energy
188 market is not well-regulated and legal frameworks are not well-developed³⁴. Strategy or planning usually starts with
189 target settings and a clear target will help specify the time scale, deployment of technologies, and corresponding
190 political measures⁴⁵. Especially the national strategies, within the APAC's political and governance environment, will
191 usually be well supported by a high-efficient implementation system to ensure their effectiveness. Government will
192 have to be more engaged with resource allocations, and adopt inclusive planning and innovative development. In
193 terms of the other policies, strategies can play a key role in framing the policy mix and take advantage of them.

194 To sum up, different energy policies have had various effects on the energy transition of different countries.
195 Countries need specific combinations of policies tailored to their specific needs to progress with the energy transition.
196 In general, we can conclude that in order to support energy access and renewable electricity capacity, strategies should
197 be prioritized. In the case of energy efficiency, countries in APAC can benefit more from legislative frameworks.
198
199

200 Discussion

201 Energy policies have significant effects on the energy transition in the APAC region, however, the region
202 requires increased action in national policy commitments for energy transition targets. The transition of energy access
203 needs a combination of improved on-grid electricity and promotion of clean cooking solutions. For example, lessons
204 can be learned from rural electrification through off-grid in Afghanistan, and the deployment of liquefied petroleum
205 gas for clean cooking in Indonesia. As a global manufacturing hub, energy efficiency improvements in the APAC
206 region rely heavily on upgrading the industrial sector, while also requiring the enrichment and deepening of policy
207 frameworks in areas such as buildings and transport, particularly through laws and strategies. In addition, the design
208 of effective combinations of policies needs to be based on country-specific endowments and the stage of the energy
209 transition they are at. For instance, institutional reforms in developing countries, such as structural reforms of the
210 electricity system, the switch from fossil fuels to renewables, rebalancing of energy supply and demand, can provide
211 policy inspiration for the energy transition in LDCs⁴⁶.

212 Progress of energy transition has also effects in terms of social welfare. By facilitating the energy transition,
213 energy policies have ultimately improved the livelihoods of people across all APAC economies in terms of both
214 access to electricity and clean cooking. For example, India has doubled energy consumption since 2000 and the IEA
215 predicts that its future energy demand will grow to reach 25% of the world demand⁴⁷. Making electricity available to
216 all is the most pressing need in India, and with the implementation of energy policies, India has provided access to
217 electricity, on average, to 121.2 million per year between 2000 and 2017, while 77.5 million people have had access
218 to clean cooking. Vietnam is one of the fastest-growing emerging economies in Asia, but the rapid economic boom

219 has been accompanied by changes in energy consumption⁴⁸. Recent energy policies have provided access to
220 electricity for the Vietnamese people, especially in rural areas that include 63% of the population, benefiting 9.6
221 million people. In addition, large segments of the APAC's population can particularly benefit from the energy
222 transition. For instance, in Philippines, Thailand and Bangladesh, 10.2, 4.8 and 2.8 million people can benefit from
223 improved access to electricity, and 6.6, 4.6 and 0.9 million people can take advantage of access to clean cooking
224 respectively.

225 Furthermore, energy policy implementation can increase benefits, and effective implementation needs to be
226 complemented by suitable policies and requires a stable political environment. Looking at the diversity within the
227 region, across countries and levels of advance in energy transition, customized policy mixes are needed. For those
228 countries at the early stage of the energy transition, such as those where electricity is not widely available, balanced
229 and strategy-oriented policies are more effective to promote electrification levels and facilitate the energy transition.
230 Regarding those countries undergoing energy transition, such as improving efficiency in the traditional energy
231 sources and deploying installed renewable energy capacity, clear strategies and active subsidies, and timely revision
232 of existing policies may help reduce the risk of policy overlap and ensure effective policy mixes⁴⁹. Meanwhile, the
233 political stability and administrative efficiency of the country can affect the realisation of the energy transition by
234 improving the credibility of policies^{50,51}. As shown in Table 1, the control variable, Political stability, is significant
235 for all indicators, suggesting that in the APAC region, the more stable the political environment, the more favourable
236 the energy transition, which is not quite the same as in developed countries that rely mainly on legislative activities³⁹.

237 Overall, to achieve the energy transition goals, economies in the APAC region need more effective energy
238 policies. Effectiveness of policies is dependent on the types of policies, monitoring, and enforcement of measures.
239 For example, the effectiveness of different types of policies also varies across jurisdictions, sectors, technologies and
240 geographic contexts⁵². Besides, inadequate policy attention also undermines the effectiveness of policies because
241 without strong policy interventions, sustainable energy progress cannot cover wider areas including the rural areas⁵³.
242 It's also worth emphasizing that policies are effective only when they are properly implemented and synergic with
243 other types of interventions or with similar policies in use in different industries. And these emerging countries may
244 seek collaborations with other countries to better exploit their resources, such as South-South cooperation, China's
245 "One Belt And One Road" policy, etc. We expect future research to draw lessons about the needed institutional
246 changes to realize energy transition in APAC or other regions in the world. Policymakers may benefit from the
247 implications of such research and accept scientific information as the basis that sets the boundaries for policy-
248 making⁵⁴, and thus improve the design of policies to build stronger connections between energy policies and the
249 energy transition they are supposed to promote.

250 Our study has a few limitations. Institutional, economic and resource endowments vary greatly from country to
251 country, and some emerging economies have issued very few policies, which may introduce bias into this study.
252 Furthermore, future policy deployment and policy-type arrangements, energy technology development, and energy-
253 economic-social impact mechanisms are still unclear but are essential to achieve the SDGs by 2030. In this sense,
254 the mechanisms of transition from energy policy to energy sector and then to energy transition should be further
255 explored in future work in order to guide policymakers in the design and evaluation of a more comprehensive policy
256 scheme. Finally, our study assumes broad policy alignment towards achievement of SDGs. Some countries may
257 occasionally elect politicians who eschew that consensus, which may lead to the promotion of discordant policies.
258 An example of such a scenario might be Bolsonaro's election in Brazil, which is not included in our analysis, but
259 could potentially confound a similar analysis made of Latin American countries.

260

261 Methods

262 The regression models

263 Our hypothesis is that a country's progress towards energy transition depends on political and socio-economic
264 factors. Models are estimated using fixed-effect panel regression as follows:

$$265 y_{it,k} = \ln(SDG_{it,k}) = \alpha + \beta ST_{it} + \boldsymbol{\gamma}\mathbf{X}_{it} + u_i + e_i \cdot v_t + \varepsilon_{it} \quad (1)$$

266 where $SDG_{it,k}$ represents the SDG 7 target k of country i at year t (see detailed descriptions about targets used
267 in the model in Supplementary Table 3). $y_{it,k}$, also defined as $\ln(SDG_{it,k})$, is the energy transition indicator. ST_{it}
268 indicates the size of policy stock. The model here also includes country fixed effects, u_i , and economic-specific
269 characteristics interacting with time-period fixed effects⁵⁵, where e_i refers to the economic development stage of
270 countries, i.e. least developed country, developing country, and transition country; v_t refers to the year fixed effects.
271 The fixed-effect model includes a full set of country and year fixed effects, which control for the unobservable
272 heterogeneity across economies in APAC. Here α represents the intercept of the model. β and $\boldsymbol{\gamma}$ are coefficients
273 of policy stock and control variables. ε_{it} is the error term.

274 The notation \mathbf{X}_{it} denotes a set of control variables listed in Supplementary Table 4. The first type of control
275 variables are economic and social variables. Here we have selected urbanization rate, GDP per capita, export share,
276 import share, and service share. Urbanization rate and GDP controls for the economic growth. Export, import and
277 service share control for the structural changes in the economy that may affect the energy transition. The second type
278 of control variable is the energy mix variable, which here is the proportion of energy imports. The third one is
279 government implementation effectiveness. We choose voice and accountability, political stability, government
280 effectiveness, regulatory quality, control of corruption and rule of law⁵⁶, ranging from 0 (lowest) to 100 (highest)
281 after normalization. For the descriptive summary and explanation of variables see Supplementary Table 5.

282 We rewrite Equation (1) to incorporate three types of policies:

$$283 \ln(SDG_{it,k}) = \alpha + \eta_p * TYP_{it,k,p} + \boldsymbol{\gamma}\mathbf{X}_{it} + u_i + e_i \cdot v_t + \varepsilon_{it} \quad (2)$$

284 where $TYP_{it,k,p}$ indicates the number of specific type energy policies p for specific target k , i.e. law ($TYP_{p=Law}$),
285 regulation ($TYP_{p=Regulation}$), and strategy ($TYP_{p=Strategy}$), the policy category is shown in Supplementary Table 6.
286 η_p indicates the coefficients of each type of energy policy.

288 The counterfactual impact of energy policies

289 Following the approach adopted in previous research (ref.^{39,57}), we construct a counterfactual scenario of energy
290 transition to quantify the overall impact of energy policies. Starting with Equation (1), we denote the estimated value
291 of the SDG7 indicators as $\hat{y}_{it,k}$. By assuming the absence of energy policies, we have a counterfactual value $\tilde{y}_{it,k}$.
292 We can obtain the aggregate effect of energy policies by subtracting the estimated value and counterfactual values:

$$293 \hat{y}_{it,k} - \tilde{y}_{it,k} = \ln(\widehat{SDG}_{it,k}) - \ln(\overline{SDG}_{it,k}) = \ln(\widehat{SDG}_{it,k}/\overline{SDG}_{it,k}) = \hat{\beta}_1 ST_{it} \quad (3)$$

294 where variable except ST_{it} is excluded from the equation. Rewriting Equation (3) by inverting the sign of the left-
295 hand side of Equation (4), we obtain:

$$296 \overline{SDG}_{it,k} = \widehat{SDG}_{it,k} \times \exp(-\hat{\beta}_1 ST_{it}) \approx SDG_{it,k} \times \exp(-\hat{\beta}_1 ST_{it}) \quad (4)$$

297 where we make another assumption about the replacement of observed SDG7 with the estimated SDG7 from
298 Equation (1). Therefore, we use Equation (4) to estimate the counterfactual scenario of energy transition without
299 energy policies.

300 Similarly, in the analysis of the counterfactual effects of sub-policy types, we treat all variables other than the
301 type under discussion as control variables. By assuming that there is no energy policy of this type, we obtain a
302 hypothetical value without energy policies as $\tilde{y}_{it,k,p}$. Based on Equation (3) and (4), we obtain counterfactual effects
303 for different policy types, shown in Equation (5) and (6).

$$\hat{y}_{it,k,p} - \tilde{y}_{it,k,p} = \ln(\widehat{SDG}_{it,k,p}) - \ln(\widetilde{SDG}_{it,k,p}) = \ln(\widehat{SDG}_{it,k,p}/\widetilde{SDG}_{it,k,p}) = \hat{\eta}_p * TYP_{it,k,p} \quad (5)$$

$$\widehat{SDG}_{it,k,p} = \widetilde{SDG}_{it,k,p} \times \exp(-\hat{\eta}_p * TYP_{it,k,p}) \approx SDG_{it,k,p} \times \exp(-\hat{\eta}_p * TYP_{it,k,p}) \quad (6)$$

306

307 **Data availability**

308 We employ three sets of data for the Asia-Pacific region over the period 2000-2017 in this study: socio-economic
 309 data, energy policy data and SDG7 indicators data. The socio-economic data are collected from the World
 310 Development Indicators database⁵⁸ and World Economic Situation and Prospects 2018³², including the level of
 311 income, country's income and geographic classifications, urbanization rate, GDP per capita, export and import shares,
 312 service shares, and energy import shares.

313 Energy policy data are collected from the *Asia Pacific Energy Portal Policy* database. The database consists of
 314 2112 energy policies from 42 emerging economies in APAC over the period 2000-2017. After collection, we collated
 315 and calculated the number of existing policies for different countries and sorted out all policies into three policy types
 316 according to the type of documents (Supplementary Table 7), which are laws (Law or Act in original policy document
 317 category), regulations (Rule or Regulation), and strategies (Strategy or Plan). If a policy includes more than one type
 318 of document, all such types will be considered in the respective stock calculations. In Fig. 4, the effect of "other" is
 319 the total policy effect minus the sum of the effects of the three types of policy, which includes Standard, Agreement,
 320 Government Report documents that are not prominent in energy policy stocks.

321 Data about the SDG7 indicators in APAC are obtained from the Global SDG Indicators Database²⁹. The
 322 renewable energy capacity data are collected from the International Renewable Energy Agency⁵⁹. We control the
 323 differences in policy implementation using a number of indicators including voice and accountability, political
 324 stability, government effectiveness, regulatory quality, control of corruption and rule of law⁵⁶, which are exported
 325 from the Worldwide Governance Indicators⁶⁰.

326

327 **Code availability**

328 Code is available on Github (<https://github.com/Peipei-Chen/Energy-policy-in-APAC/>).

329

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334

335 **Author Contributions Statement**

336 P.C., Y.W. and J. M designed the research. P.C. and Y.W. collected the data. P.C. and J.M. led the study and draft
 337 the manuscript with efforts from all authors (P. H., D. L., D.C, X.L. and D.G.). P.C., P.H. and D.L. constructed the
 338 statistics model.

339

340 **Competing Interests Statement**

341 The authors declare no competing interests.

342

343 **Table**

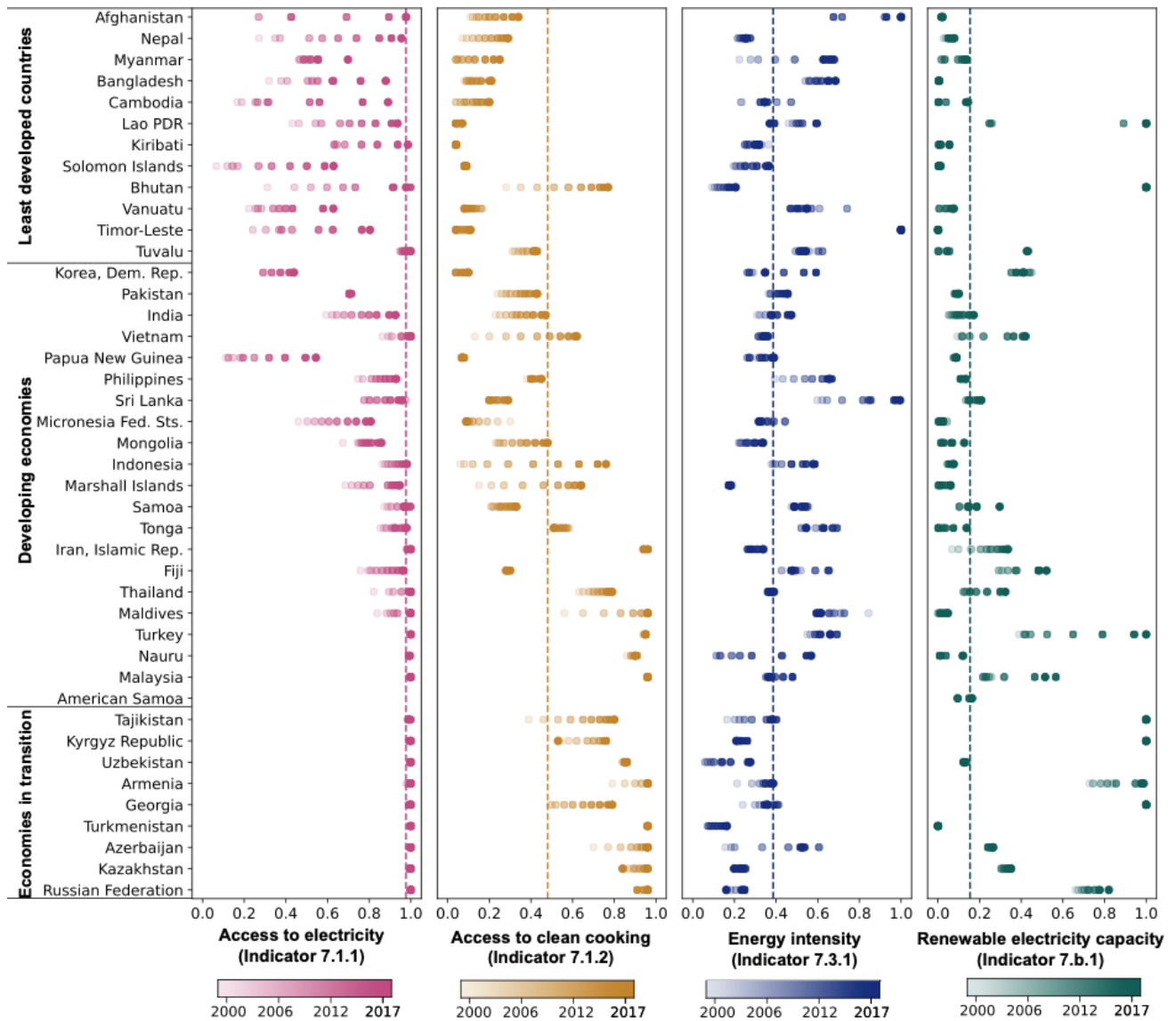
344 **Table 1.** Effect of energy policies on energy transition.

VARIABLES	Access to electricity (Indicator 7.1.1)	Access to clean cooking (Indicator 7.1.2)	Energy intensity (Indicator 7.3.1)	Renewable electricity capacity (Indicator 7.b.1)
Policy stock	0.001*** (0.000)	0.002* (0.001)	-0.001** (0.000)	0.003** (0.001)
Urbanization rate	-0.008* (0.004)	0.023*** (0.006)	0.005 (0.003)	0.019*** (0.005)
GDP per capita	-0.037 (0.041)	0.672*** (0.192)	0.264** (0.118)	0.551** (0.192)
Export share	0.000 (0.000)	-0.003** (0.001)	0.003*** (0.001)	0.001 (0.003)
Import share	-0.000 (0.000)	0.005*** (0.002)	0.001 (0.001)	0.002 (0.002)
Service share	0.002 (0.002)	0.004 (0.004)	0.015*** (0.002)	0.007* (0.003)
Energy import share	0.000 (0.000)	-0.000 (0.000)	0.001*** (0.000)	0.000 (0.000)
Voice and accountability	-0.204** (0.074)	0.654*** (0.124)	-0.094 (0.128)	-0.889*** (0.200)
Government effectiveness	0.017 (0.043)	-0.126 (0.105)	-0.161 (0.103)	0.508** (0.225)
Political stability	0.218*** (0.049)	0.593*** (0.108)	-0.361*** (0.074)	0.391** (0.149)
Regulatory quality	0.016 (0.060)	0.380*** (0.070)	0.109 (0.075)	0.340 (0.279)
Control of corruption	-0.139 (0.090)	-0.035 (0.181)	-0.064 (0.061)	-0.721** (0.287)
Rule of law	0.039 (0.091)	0.043 (0.284)	0.192 (0.120)	0.120 (0.311)
Constant	4.658*** (0.183)	1.574** (0.575)	0.724*** (0.165)	2.504*** (0.435)
Observations	295	313	313	313
R ² (within)	0.872	0.704	0.766	0.531
Country FE	YES	YES	YES	YES
Year*economic status FE	YES	YES	YES	YES

345 *Note:* (1) Standard errors in parentheses, (2) Statistical significance levels: *** p<0.01 (1% level), ** p<0.05 (5% level), * p<0.1 (10%
346 level), (3) Independent variables in the models are lagged by one period, (4) Dependent variables are in logarithm form.

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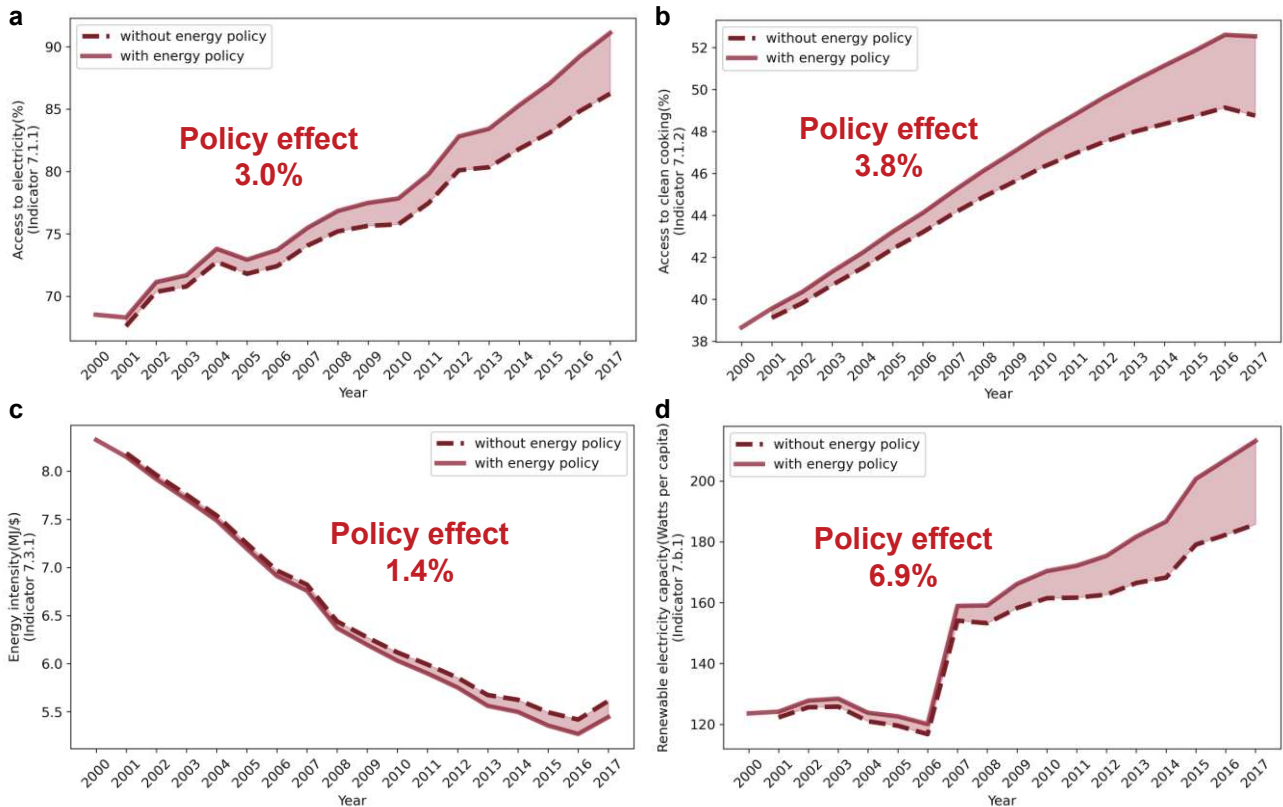


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351 **Fig. 1 Progress toward energy transition in the APAC emerging economies during 2000-2017.**

352 Values ranging from 0 to 1 represent the progress towards the energy transition targets, i.e. the ratio of the annual value of
 353 the indicator over the target value defined in the Global SDG database (low energy intensity values represent high
 354 indicator scores), the higher the value, the higher the level of progress towards the energy transition targets. A value of 1
 355 means the target is met. The dashed lines in the figure show the median value of the standardised progress for each target
 356 in 2017. Countries within each economic development category are ranked from lowest (top) to highest (bottom) in terms
 357 of the average GDP per capita over 2000-2017. Here PDR means People's Democratic Republic; Korea, Dem. Rep. means
 358 Democratic People's Republic of Korea; Micronesia Fed. Sts. means Federated States of Micronesia.

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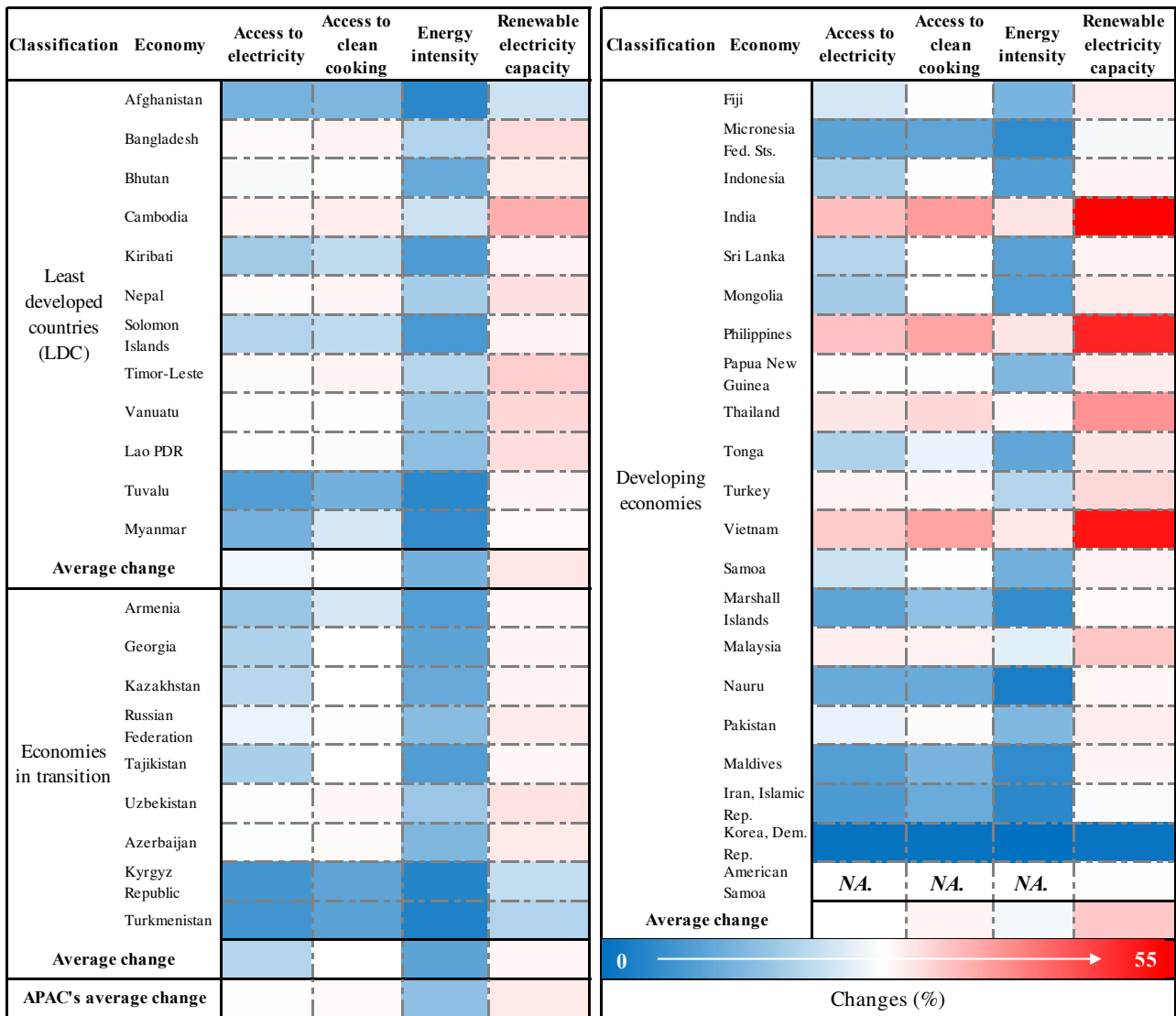


360

361 **Fig. 2 Performance of APAC emerging economies' energy transition with and without energy policy.**

362 The calculation goes from 2000 to 2017 because the basic model is lagged by one year. Observed SDG7 performance
 363 is represented by solid lines. Counterfactual performance is represented by dashed lines. **a**, the performance of access
 364 to electricity (Indicator 7.1.1). **b**, the performance of access to clean cooking (Indicator 7.1.2). **c**, performance of
 365 energy intensity (Indicator 7.3.1). **d**, the performance of renewable electricity capacity (indicator 7.b.1). The values
 366 in the figure indicate the percentage change in the average of indicators without energy policies to the average with
 367 energy policies, thus reflecting the effect of the energy policy (for energy intensity, energy policy lowers this indicator;
 368 but for the energy efficiency target, policy effect is a positive improvement).

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Fig. 3 Impact of energy policies on energy transition by country during 2000-2017.

The coloured cells show the range of dispersion of the difference between energy transition with and without energy policies, across different economies. The colours indicate the percentage of changes. For energy intensity, changes are negative as lower intensity means higher energy efficiency.

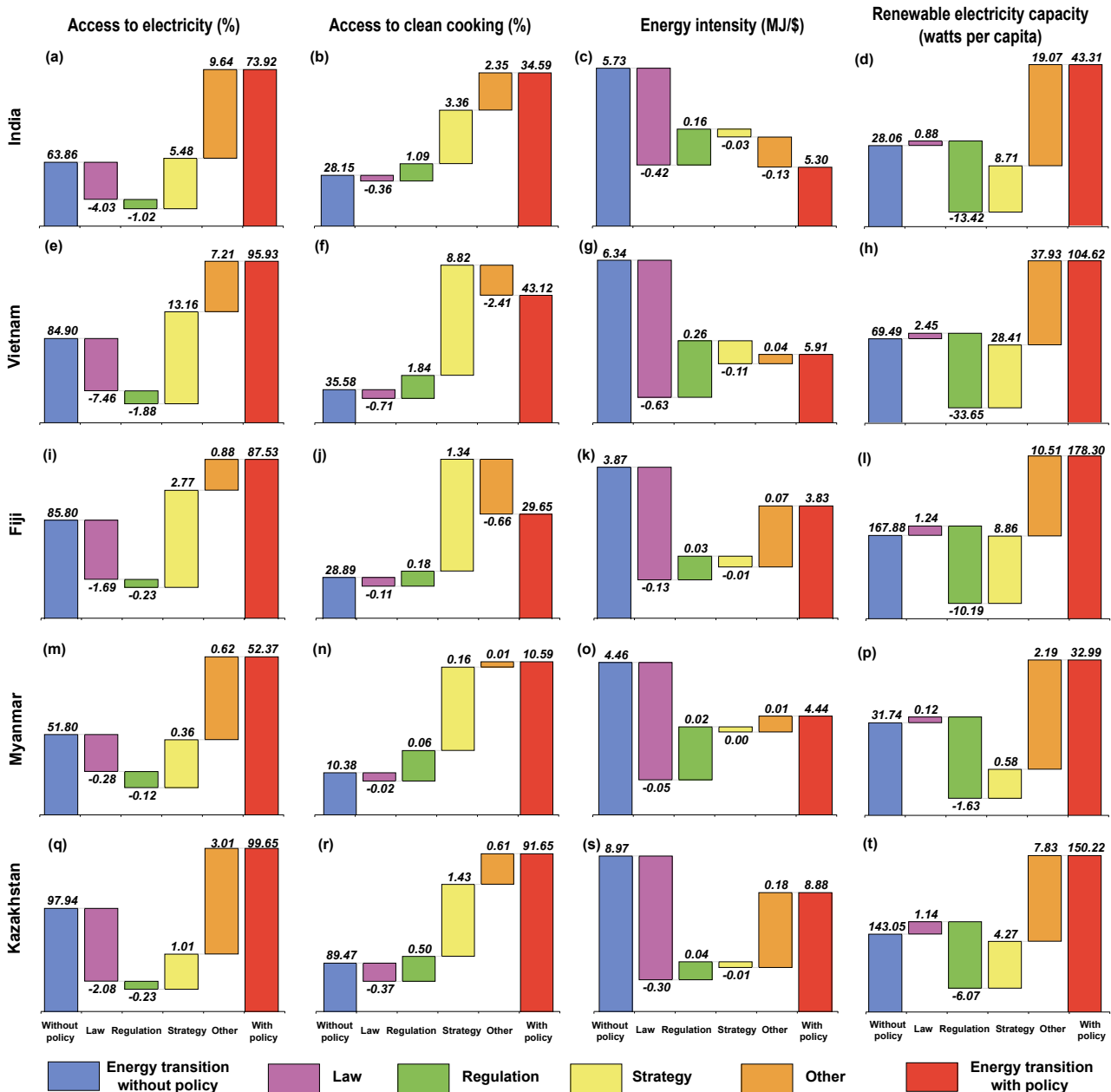


Fig. 4 Impact of different types of energy policies on energy transition in typical economies.

Assessment of energy transition indicators (access to electricity, access to clean cooking, energy intensity and renewable electricity capacity) with and without policy in developing country India (a-d), developing country Vietnam (e-h), developing country Fiji (i-l), least developed country Myanmar (m-p), and transition country Kazakhstan (q-t), including the contributions of law, regulation, strategy, and other types of policies. The numbers above the first and the last bar in each panel, “Without policy” and “With policy”, indicate the values of the energy transition indicators for each country (the units of the indicators are shown at the top of the figure), and the numbers above or below other bars indicate the change in the values caused by four types of policies (the units are as the same of indicators at the top of the figure).

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Supplementary information

Supplementary Information

Supplementary Figures 1–3 and Supplementary Tables 1–8.