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Most of the world's coal reserves should be left in the ground to avoid catastrophic global warming, the UN's climate chief has told the \$3tn global industry.

In a speech to a gathering of industry executives, Christina Figueres challenged the industry to urgently transform itself, diversify into renewable energy and "radically change ... rapidly and dramatically for everyone's sake".

"By now it should be abundantly clear that further capital expenditures on coal can go ahead only if they are compatible with the 2C limit", she said at the international coal and climate summit in Warsaw, being held at the same time as UN climate talks.

Figueres said they had "the opportunity to be part of the worldwide climate solution" by switching off old coal power plants, capturing and storing carbon from new plants and leaving most of the world's coal reserves in the ground. She also said coal power could help poorer countries' economic development and poverty reduction, but that the industry "must change".

"I urge every coal company to honestly assess the financial risks of business as usual; anticipate increasing regulation, growing finance restrictions and diminishing public acceptance," she said.

Figueres was later backed by the energy minister, Greg Barker, who is in Warsaw for the UN negotiations. "Coal represents the biggest threat to climate stability in the medium term. If we can keep coal in the ground it could have a profound impact on the growth of the world economy. The question is how do we keep unabated coal in the ground," he said.

But Barker backed gas over renewables. "Gas is the way to ensure we burn less coal over the next two decades," he said.

At a later press conference, Figueres said the industry needed a "deep, deep transformation" and should reinvent itself as a developer of renewable energy.

"They really need to do a major, major rethink and a major shift in the deployment of their capital [towards renewable energy] ... there is no doubt they are the energies of the future," she said.

Her remarks took both the coal industry and environment groups by surprise. The industry had invited her to talk in expectation that she would legitimise their continuing growth if they adopted new technologies. The activists had been critical of her talking to the industry at all.

But it is thought Figueres was stung by insistent youth groups at the UN conference who reportedly admonished her for being prepared to talk to the coal industry but not to them. In a nod to their presence, she called on the industry to "see the next generation's bottom line".

The industry declined to respond directly but argued that significant emissions reductions could be achieved by improving the efficiency of coal-fired plants using "high efficiency" coal.

But this was rebutted by a group of 27 international scientists meeting in Warsaw who agreed with Figueres, saying that nearly 75% of the world's coal reserves had to be left in the ground if global warming was to be limited to a 2C rise.

In a joint statement, the scientists – from the US, Germany, Japan, China, India, Brazil and South Africa – rebutted claims that high-efficiency coal can be a low-emissions technology.

Using International Energy Agency estimates of world coal reserves, the group said that burning just 26% of the reserves would break the global "carbon budget", lifting temperatures above the 2C threshold which has been adopted as a goal for the UN climate talks.

"We are not saying there is no future for coal", said ProfessorPR Shukla of the Indian Institute of Management, "but that unabated coal combustion is not compatible with staying below the 2C limit." Milton Catelin, chief executive of the World Coal Association, said: "We're not going to meet our climate objectives if we are not all part of the solution. Ms Figueres has shown she shares the WCA's view that multi-stakeholder dialogue is key to tackling climate change."

Martin Kaiser, Greenpeace's international climate director, welcomed the speech. "She gave the right warning to investors that any new investment into coal-fired power plants is a financial risk as there will be increasing regulation, growing finance restrictions and diminishing public acceptance."