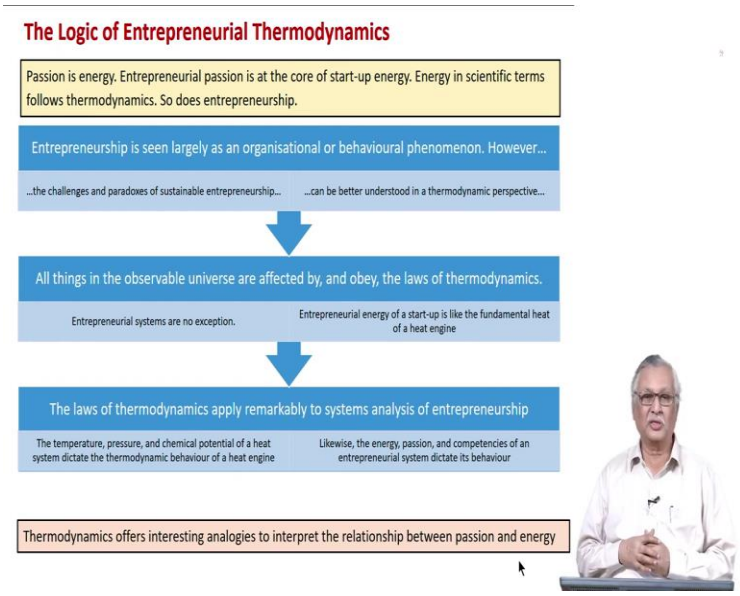
Entrepreneurship
Professor. C Bhaktavatsala Rao
Department of Management Studies
Indian Institute of Technology, Madras
Lecture 48
Entrepreneurial Thermodynamics Part 1

Hi friends, welcome to this course on Entrepreneurship. Over the past several sessions we have considered different aspects of entrepreneurship, how an entrepreneurial firm is set up, what is the kind of journey does an entrepreneur have, the role of technology, the role of finance, the role of government policy, the dynamics amongst various stakeholders, the role of educational institutions in entrepreneurship, the national entrepreneurship culture, and various other aspects.

In this session, we will consider one very unique aspect of entrepreneurial dynamics, which I titled as Entrepreneur Thermodynamics. I would imagine that this is a very unique way of looking at entrepreneurship and probably this would add to our analysis and understanding of the complex subjects of entrepreneurship.

We all know what thermodynamics is, thermodynamics is nothing but study of energy. How heat energy is converted or expressed in terms of various other forms of energy like mechanical energy, electrical energy, chemical energy, and so on. In a more expansive way, thermodynamics deals with all, in an expansive way thermodynamics deals with all forms of energy and the interactions, the principles and rules governing the thermodynamic properties of various materials.

(Refer Slide Time: 01:44)



Now, why entrepreneurship should be seen in a thermodynamic context or through a thermodynamic filter, the logic of entrepreneurial thermodynamics is very simple. The simplicity arises because entrepreneurship is driven by passion and energy. And look at it, passion and energy are very similar in nature and are synergistic to each other. Entrepreneurial passion is the core of start-up energy and energy as we know in scientific terms follows thermodynamics. Similarly, entrepreneurship also follows thermodynamics.

We tend to see entrepreneurship basically, in terms of an organizational or behavioral phenomenon. Organizational, in terms of setting up a start-up firm, and behavioral in terms of entrepreneur being as very unique type of professional, who wants to set up his own or her own enterprise.

However, the challenge of setting up an entrepreneurial venture can be better understood when we look at the whole process through a thermodynamic perspective. We know that all processes in the observable universe are affected by, influenced by and also obey the laws of thermodynamics, entrepreneurial systems are no exception.

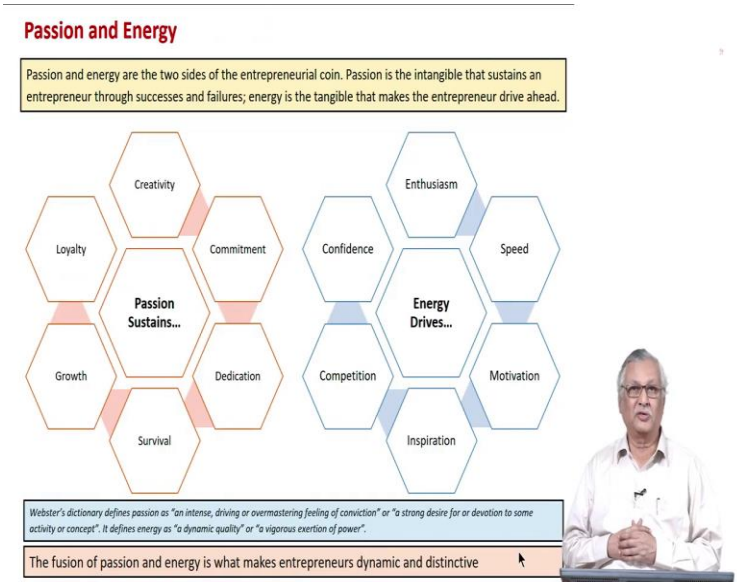
Entrepreneurial energy is very unique to start-up and entrepreneurial energy of a start-up is akin to the heat energy of a heat engine. What is a heat engine, heat engine is any

device which uses heat to convert itself into mechanical energy. So, internal combustion engine is a heat engine, the railway steam engine is a heat engine. So, any engine which uses one form of power to move is a heat engine. So, entrepreneurial energy helps the entrepreneurial venture to move itself on the path of entrepreneurial development.

Therefore, the laws of thermodynamics, in my view apply remarkably to a system's analysis of entrepreneurship. We have the temperature, the pressure, the chemical potential of a heat engine and they determine the thermodynamic behavior of a heat engine. Similarly, the energy, the passion, the competencies set of entrepreneurial start-up dictate its behavior.

Therefore, the science of thermodynamics, the practice of thermodynamics offers interesting analogies to us to interpret the relationship between various forces that impact, that influence entrepreneurship. And principally the two, the two forces which we are going to consider here are the passion and energy.

(Refer Slide Time: 04:34)



Now, what is passion and what is energy, passion and energy to a mind are two sides of the same coin, the same entrepreneurial coin. Passion is an intangible asset, an entrepreneur or an entrepreneurial firm possesses. It is that force or that intangible

characteristic, the intangible DNA of the firm and the entrepreneur that sustains an entrepreneur through successes and failures, all thorough the vicissitudes of the journey.

Analogous to that, energy is the force that drives the entrepreneurial firm and entrepreneur forward, in terms of the growth, in terms of product development and various other facets of entrepreneurship we considered.

Webster's dictionary defines passion as an intense driving or overmastering feeling of conviction. I quote again; passion is a strong desire for or devotion to some activity or concept. That means that people who are passionate, firms which are passionate, believe in something and they stand committed to that and come what may, they hold on to that passion. It also defines energy as a dynamic quality that is a quality that is capable of exhibiting dynamism and also as a vigorous exertion of power.

So, when we have passion and energy as two sides of the same entrepreneurial coin, let us see what passion does and what energy does. Passion basically sustains the ability to last through several crises, several opportunities, several highs of entrepreneurial journey as well as several lows of an entrepreneurial journey.

So, what does passion sustain, it sustains fundamentally creativity. It is very easy to lose creativity when you have all sorts of obstacles in your way. So, passion, commitment to the cause sustains creativity. So, the other aspect of passion is commitment, that I needed to solve this problem through my product or service and I should stand committed to that.

The other aspect of passion, which is sustained is dedication, dedication to a cause. Passion also sustains a survival instinct because when chips are down, you need to do a few things differently to be able to survive and later on grow. So, the survival instinct, the survival capability is also sustained by passion. Then of course, passion sustains growth momentum or growth aspiration. And more importantly again, passion sustains loyalty, loyalty to a cause.

Entrepreneurs, who are committed to a particular cause, are also loyal to the cause. And, even if there are certain pointers, which may indicate that the whole exercise may not be as profitable as what was considered to be, but the founder still remains loyal to the cause

because the founder believes that sooner or later, he would find even better way of executing his plan. So, passion sustains six forces, which are creativity, commitment, dedication, survival, growth and loyalty, these are very important.

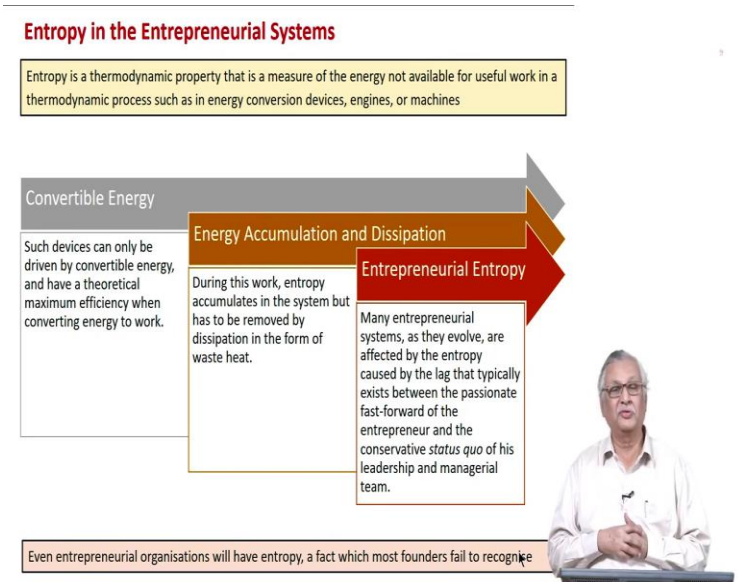
What does energy do, energy does similarly three things. One, it provides the basic enthusiasm in the organization and in the founder that they should move along. Second, it provides speed, the velocity, the agility of the company. It provides the motivation because only when you are energetic as a founder, you can motivate and also as we see next, inspire the organization.

Motivation and inspiration are little different. Motivation is something which promises an outcome and therefore, it motivates their team to work towards that objective or the outcome. Inspiration, on the other hand is something which is very intrinsic to the leadership behavior of the founder and the leadership behavior inspires the team to work towards that goal. It is like Mahatma Gandhi, our father of nation inspiring through his moral leadership model and also various other thematic excellences which he had.

Energy also drives competitive behavior of the company because to be able to compete with other firms, the established firms as well as the other start-ups you need to be competitive and you should possess some kind of competitive advantage. And, the speed with which you move, the energy with which you execute your actions also provides a self-sustaining level of confidence in the company.

So, energy drives six other aspects which are, enthusiasm, speed or agility, motivation, inspiration, competition, and also confidence. So, when you have passion sustaining six very important aspects of entrepreneurship and when energy drives another six important aspects of entrepreneurship, you can see the synergistic impact of passion and energy helping the entrepreneurial company to move ahead. So, the fusion of passion and energy is what makes entrepreneurs very unique and very distinctive in the overall leadership canvas of an industry.

(Refer Slide Time: 09:53)



Now, when we talk about heat, when we talk about thermodynamics, when we talk about work being done, we cannot also ignore one very important concept of entropy. There is entropy in heating, there is entropy in all devices. There is also entropy in the overall universe itself. Obviously, there will be entropy in entrepreneurial systems as well.

Entropy is a thermodynamic property that is a measure of energy that is not available for useful work in a thermodynamic process, such as in energy conversion devices, engines or machines. When we look at engines, we talk about certain level of thermal efficiency, when we talk about steam engines, we talk about a level of thermal efficiency, when we talk about light bulbs, we talk about a level of energy efficiency.

So, energy efficiency means the energy which is actually available for realization or for the deployment for the intended use versus the energy which is available theoretically as a maximum. So, energy efficiency is a percentage or a function of the available energy as expressed in terms of useful energy. So, the difference between theoretically available energy and actually realizable energy represents what we call entropy.

Many devices can be done or all devices can be driven only by convertible energy and they have a theoretical maximum efficiency when converting energy to work. And, we know through the study of design of devices, through design of engines that the higher

the tolerances, the higher the quality of fuel, the higher the quality of combustion, we will be able to improve the efficiency of the engine. But probably we will never improve that to 100 percent. So, there is bound to be some level of entropy in an thermodynamic engine at any point of time.

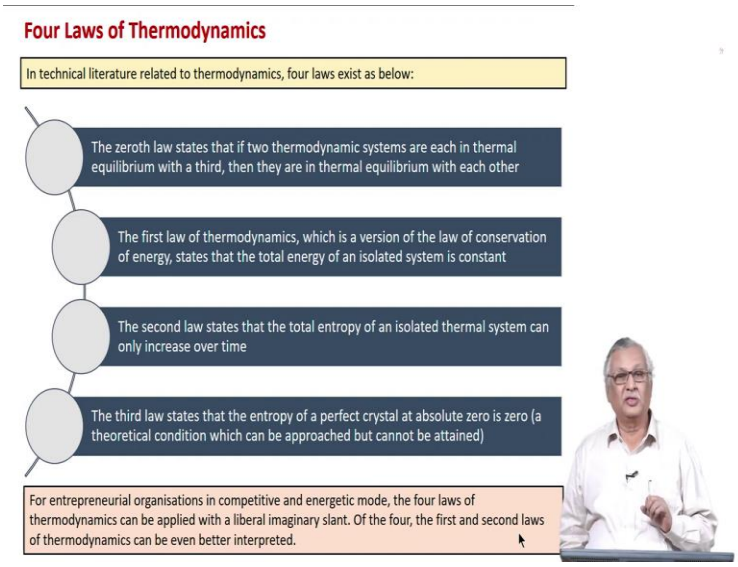
So, during this work of converting useful energy into work, entropy accumulates in the system and that entropy has to be dissipated in the form of waste heat. It is not that the entropy remains in the heat engine. When we touch a heat engine, when we see the engine exhibiting, exuding heat to the environment, the waste heat is getting dissipated, which was there earlier as entropy is getting dissipated as waste.

So, when we talk about entrepreneurial entropy, we have to consider entropy as an inevitable consequence of any organizational activity, any inevitable consequence of organizational work. So, many entrepreneurial systems as they evolve, as they grow are also affected similarly. They are affected by the entropy that is caused by the lag between the energy of the founder vis-a-vis the energy of the entrepreneurial firm, that is the rest of the team. Because, the definition of an entrepreneurship is that the founder exhibits the maximum possible amount of energy, passion to drive the company forward.

It is not necessary that as the company grows larger, as the company grows bigger, not the team, or even individual members would be able to match the energy level of the founder. So, the difference between the energy level symptomatically and symbolically of the founder vis-a-vis with the energy level exhibited on an average by the team, that represents the entropy.

However, most founders, most entrepreneurs fail to recognize that even organizations will have entrepreneurial entropy. And, they tend to believe that the organizations are going to work to the same level of passion and same level energy as they individually perform. So, the recognition of entrepreneurial entropy is also one of the important aspects of entrepreneurial reflection or introspection.

(Refer Slide Time: 14:04)

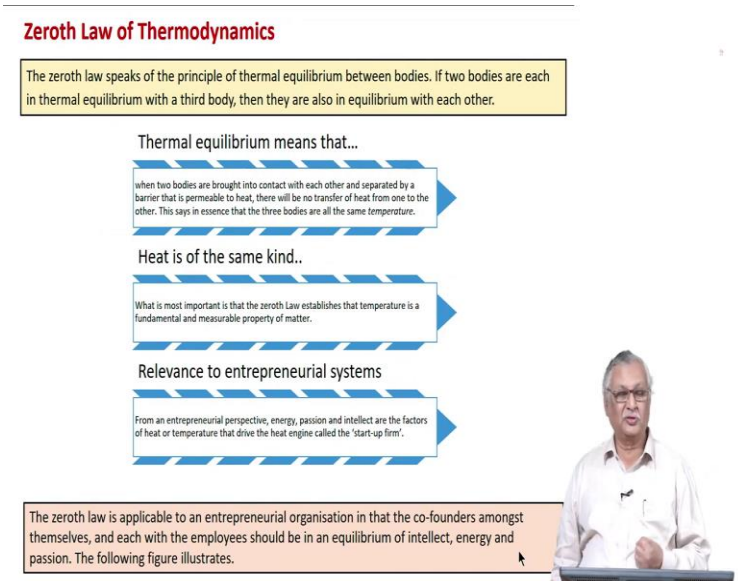


So, when we say that we will interpret entrepreneurial activity or the whole phenomenon of entrepreneurship through the lens of thermodynamics, we need to also consider what are the four laws of thermodynamics. So, I will read them out.

The zeroth law of thermodynamics states that if two thermodynamic systems are each in thermal equilibrium with a third, then they are in thermal equilibrium with each other. The first law of thermodynamics, which is a version of the law of conservation of energy, states that the total energy of an isolated system is constant. The second law states that the total entropy of an isolated thermal system can only increase over time. And finally, the third law states that the entropy of a perfect crystal at absolute zero is 0, a theoretical condition which can be approached but cannot be attained.

For entrepreneurial organizations which are in competitive and energetic mode, the four laws of thermodynamics can be applied; of course, with some philosophical stance. Of the four laws of thermodynamics, the first and second laws are even more applicable. Let us examine in the subsequent discussion as to how these are applicable.

(Refer Slide Time: 15:16)



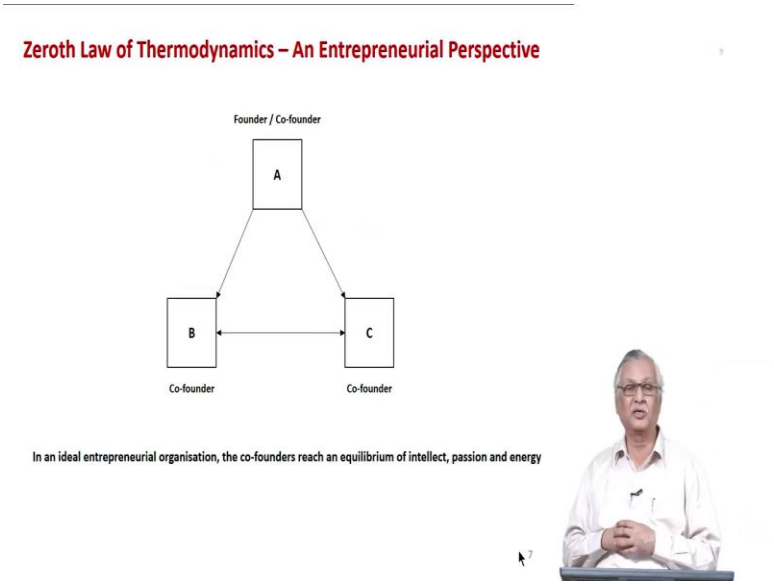
First of all, what is the zeroth law of thermodynamics, it talks about the principle of thermal equilibrium between bodies. It says that if two bodies are each in thermal equilibrium with a third body, they are also in equilibrium with each other.

So, thermal equilibrium means that when two bodies are brought together with, with a barrier which is permeable to heat, there will be no transfer of heat from one to the other. This says in essence that the three bodies are all the same temperature.

And heat is also of the same kind, it establishes that temperature is a fundamental and measurable property of matter. You touch anything; you will find the level of temperature; it is a fundamental property of all physical matter. And why is it relevance to entrepreneurial system, energy, passion, and intellect are the factors which are analogous to heat or temperature that drive the heat engine called the start-up firm.

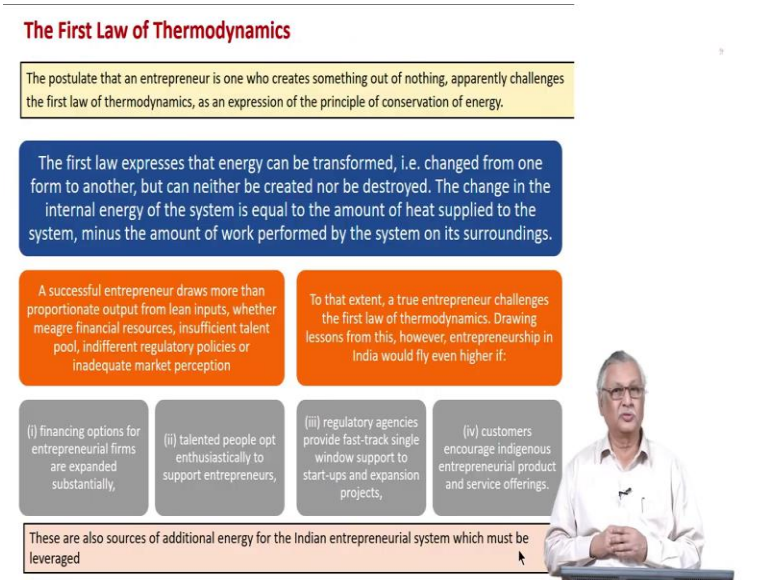
So, this zeroth law is applicable in terms of the thermal equilibrium to the entrepreneurial firm because the founder and the co-founders and the co-founders amongst themselves, the founder team and the rest of the team, must all be in thermal equilibrium; an equilibrium that is characterized by intellect, energy, and passion.

(Refer Slide Time: 16:34)



So, we have this very simple diagrammatic representation of what happens. So, we have a founder, who can also be a co-founder, we have two other co-founders. So, in an ideal entrepreneurial organization, the co-founders reach this thermal equilibrium. In this case, an equilibrium of intellect, passion, and energy. And, as we expand this network of thermal equilibrium, you will find that the entire organization can be thermo-dynamically in state of equilibrium.

(Refer Slide Time: 17:05)



So, let us come to the first law of thermodynamics. There is this postulate that an entrepreneur is somebody who can create something out of nothing, which seems a very interesting way of explaining entrepreneurship. But it is not necessarily true, because nothing can be created out of a vacuum. So, something is required to create something else, it maybe, so it challenges the first law of thermodynamics as a principle of conservation of energy.

And, what does the first law says, the first law says that energy can be transformed, that is from, that it can be changed from one form to another, but it can neither be created nor destroyed. The change in the internal energy of the system is equal to the amount of heat supplied to the system, minus the amount of work performed by the system on its surroundings.

So, the internal energy of a system or of a heat engine is equal to the amount of heat that has been provided as input to the system, minus the amount of work performed by the system on its surroundings. So, a successful entrepreneur, in a manner of saying, draws more than proportionate output from lean input. And the more he does that, the more thermally efficient, more entrepreneurial efficient the organization would be.

And the inputs could be financial resources, talent pool, regulatory support, or market perception. They may be weak, but the ability to bring out strong performance out of these weak inputs is characteristic of an entrepreneurial system. So, to this extent, a true entrepreneur challenges the first law of thermodynamics.

Drawing lessons from this, however, entrepreneurship in India would fly even higher if we do four things. First thing to do, financing options for entrepreneurial firms should be expanded substantially; so that entrepreneurial firms need not struggle with weak financial resources. And, we have already seen that even with weak resources, entrepreneurs are capable of providing much more proportionately higher output.

If a large organization would like to do a particular project, they would think of, let us say 100 crores. But an entrepreneurial firm would be in a position to do that even with 10 crores. So, that is the kind of 10x advantage which an entrepreneurial firm could provide

to a particular task. Therefore, if the entrepreneur firm has got better finances, its ability to leverage the higher finances for a even higher output is self-evident.

Secondly, entrepreneurship system requires talented professionals to join the entrepreneurial mainstream. We have considered in the earlier discussions how in the Indian educational system there has been so much emphasis on formal education and formal employment. Therefore, not always the best are get drawn to the entrepreneurial system.

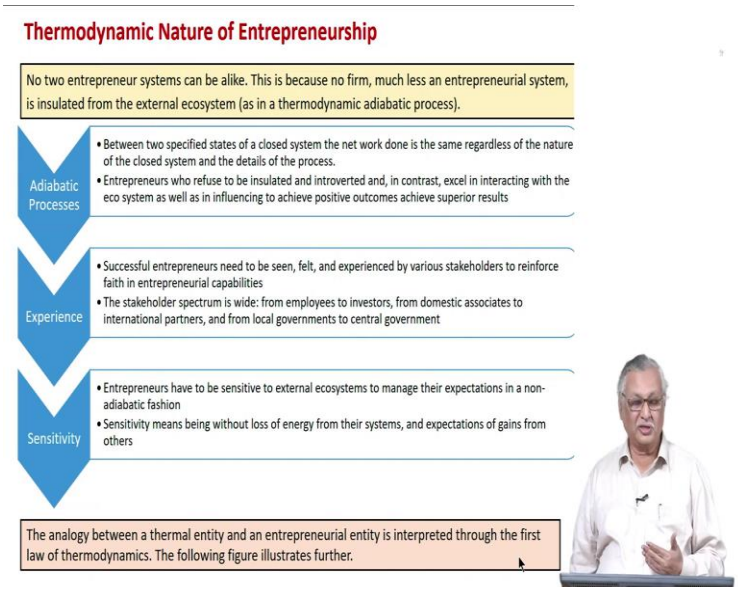
However, if entrepreneurship takes place in the nation's DNA as a national entrepreneurial culture, a topic which we considered earlier, talented pool of people can join entrepreneurial mainstream much more willingly, and much more enthusiastically, that will provide greater leverage for the entrepreneurs to develop and deliver more successes.

Third, regulatory agencies provide fast-track single window support to start-ups and expansion projects. Any time expended in getting things done, any delays experienced in moving things forward or any controversies, debates we have in terms of execution of the right policies, we all mean entropy that has been injected into the entrepreneurial system. So, the smoother the policies are, the smoother the regulations are, the greater would be the entrepreneurial effectiveness.

And fourthly, when customers look at entrepreneurial products with a fair eye, with an objective eye, without bias that these are not coming from big companies, then there would be an improved market perception on product and service offerings that are provided by entrepreneurs.

So, when these four things happen, that is easier financing options, more talented people joining the entrepreneurial firms, more supportive regulatory policies, and a favorable market perception towards entrepreneurial products, then the entrepreneurial energy that can be unleashed will be even higher. So, there could be other sources of energy for entrepreneurial system, but these are the four principal sources of energy.

(Refer Slide Time: 21:43)



So, what is the thermodynamic nature of entrepreneurship, the thermodynamic nature of entrepreneurship varies from entrepreneurial company to another entrepreneurial company, because no firm in the normal milieu, much less in the entrepreneur system is insulated from the external ecosystem. And, that happens as a thermodynamic adiabatic process.

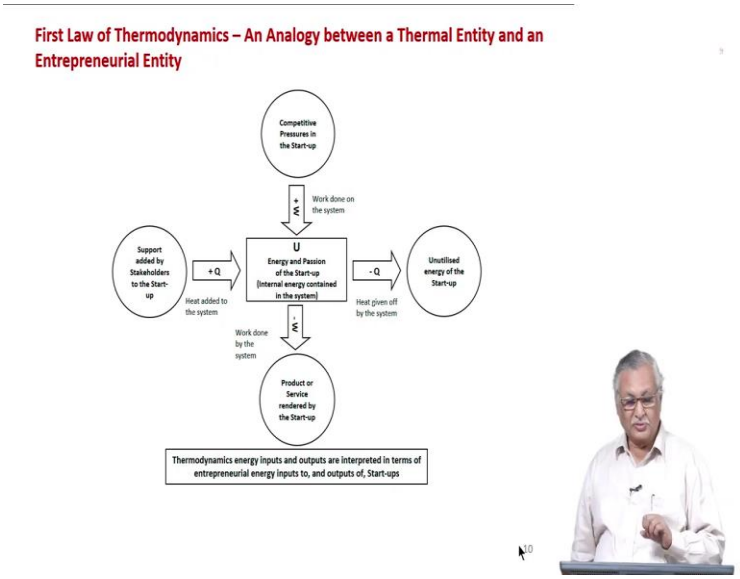
Between two specified states of a closed system, the net work done is the same regardless of the nature of the closed system and the details of the process. So, entrepreneurs who refuse to be insulated and introverted, and in contrast, excel in interacting with the external ecosystem, and also excel in influencing the external ecosystem achieve more positive outcomes and achieve more superior results compared to people who lured themselves to be insulated and introverted. So, that is an adiabatic process of thermodynamics, which is relevant for entrepreneurs.

Second one, experience. Successful entrepreneurs need to be seen, felt, and experienced by various stakeholders; it is like the environment feeling the heat engine. They need to be felt and experienced by various stakeholders to reinforce the faith in entrepreneurial capabilities. And the stakeholder spectrum that needs to experience and entrepreneur and the entrepreneurial firm is indeed wide, employees, investors, domestic associates, international partners, local governments, and central government to just quote a few.

Then, sensitivity. The entrepreneur should be very sensitive to the external ecosystems to manage the expectations in a non-adiabatic fashion. Sensitivity means what, sensitivity means being in a state that does not have loss of energy from their systems, and that also is not unduly motivated by expectations of gains from others.

So, sensitivity is in a way, the state of stithaprajna as we may call it in Sanskrit. That is also an important characteristic of entrepreneurial thermodynamics. So, the analogy between the thermal entity and the entrepreneurial entity can be thus interpreted through the first law of thermodynamics. The following figure illustrates this further.

(Refer Slide Time: 24:09)



So, at the core is the entrepreneurial box or the heat system or the heat engine, the start-up firm. For the firm, you get the competitive pressures in the start-up. Work is done on the system and the start-up firm delivers the product or services. So, the start-up firm does work on this system, by the system. So, you have competitive pressures serving as the work done on the system and we have the heat engine or the entrepreneurial start-up firm doing the work and delivering a product or service.

Then, there is support which is added by various stakeholders, which is the heat added to the system. And, there is also frictional loss or other losses which are experienced in the system, which is the unutilized energy of the start-up, that is heat given off by the system.

So, when you have thermodynamic energy inputs and outputs, in terms of the energy inputs and outputs of the start-up engine, you will find a thermodynamic equation. And, founder can really optimize, which inputs should be asked for, which input should be leveraged and which kind of output should be delivered and how to minimize the waste to the system, as also draw an additional inputs from the support U stakeholders.