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## **Energy of Reindeer Breeding: Driving Actions in the Controlling Impacts in Ecological and Ethno-Social Contexts**

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*Sustainability of socio-ecological systems is ensured, firstly, through relatively powerful energy flows associated with the interaction of material components, and secondly, through the low energy controlling impacts that drive these flows. Reindeer herding is based on traditional patterns of controlling the flow of biological matter and energy that have developed in different ethnic communities and different types of geographic landscapes (“tundra feeds reindeer, reindeer feeds man”). These models include sustainable sets of traditional practices, including various methods of individual and group taming of animals, direct and indirect methods of controlling their behaviour, spatio-temporal models of seasonal movements of reindeer herds, etc. All together, they provide a symbiosis between reindeer herder communities and populations of domesticated reindeer.*

*The energy of traditional reindeer breeding is based, on the one hand, on optimal strategies of movement in space, which allows obtain the maximum effect from the use of pasture fodder resources by optimizing the reindeer bodily heat balance. On the other hand, it is connected with the traditional practices, which help to save effort and energy in reindeer herd management. Adaptation of traditional reindeer breeding to industrial and post-industrial society is expressed in the transition to “gasoline” and “digital” reindeer herding. The first transition is accompanied by a dramatic increase in the systematic energy consumption, and the second, apparently, will lead to their reduction.*

*Keywords: reindeer herding, indigenous peoples, climate, heat balance, traditional practices, socio-ecological systems, North of Russia, Siberia.*

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The socio-environmental systems' energy issues come to the agenda due to the global warming processes that require the society to work more on energy saving. The research requires consideration of a wide range of questions, since the sustainability of the global ecosystem is determined by a combination of multiple natural, economic, and social factors. Though reindeer herding does not seem to play any significant role in the energy of global processes, this is not the only possible point of view. Thus, N. S. Zimov (Zimov et al., 2009) proves that the increase in the headcount of ungulates, and particularly, reindeer in tundra ecosystem slows down the permafrost degradation and may make a considerable contribution into the decrease of CO<sub>2</sub> emissions into the atmosphere. In the long run, it may make a positive influence on the heat balance of the planet as a whole.

The energy of ecosystems is based on the mechanisms that transfer energy down the food chain from the organisms of a lower trophic level (producers) to those of a higher level (consumers). This concept also applies to the socio-ecological systems, where the energy processes fall under the controlling impact of the society. The sustainable functioning of such systems is ensured through regulation of the powerful streams of energy linked to the interaction of material components with low energy controlling impact. The socio-ecological system of reindeer breeding consists of pasture lands, a herd of deer and operating staff, a group of people perpetually engaged in the maintenance of the herd (Krupnik, 1989). Within the system, producers are fodder plants of the reindeer pastures; reindeer act as first order consumers, and human is a second order consumer. Reindeer herding is based on traditional patterns of controlling the flow of biological matter and energy that have developed in different ethnic communities and different types of geographic landscapes ("tundra feeds deer; deer feeds man"). These models consist of the sustainable and typically repeated traditional practices, reproduced in similar geographic conditions. These models include sustainable sets of traditional practices, including various methods of individual and group taming of animals, direct and indirect methods of controlling their behaviour, spatio-temporal models of seasonal movements of reindeer herds, the spatial structure changes by means of fences, restriction of head counts of other animals (wild deer, predators) etc. All together, they provide a symbiosis between reindeer herder communities and

populations of domesticated reindeer (Beach, Stammer 2006: 8; Istomin, Dwyer, 2010; Stépanoff, 2012). As a result of a compound set of accultural processes, the symbiosis of the traditional herder communities and the regional environment is continuously transforming: it is intruded by the new energy flows that make a significant impact both on the ethnocultural environment and the essence of energy relations between the main components of the system. These changes occur against the background of the slower natural trends entailed by the global climate change.

The objective of this article is to identify and qualitatively explain the main mechanisms ensuring the energy efficiency of traditional reindeer herding systems. We attempted to answer the following questions:

How do the energy mechanisms in the traditional reindeer herding systems work?

What changes occur in these mechanisms as a result of integration of reindeer breeding into the industrial and post-industrial society?

The reindeer breeding energy shall be considered in three contexts: the ethno-ecological one with respect to the climatic conditions, the ethno-economic and ethno-cultural ones.

The input information is the literature sources, results of the author's field research carried out in various reindeer herding areas in the European North, Yamal, Chukotka, Evenkia, the Irkutsk Oblast, as well as the results of reindeer heat balance mathematic simulation results for the tundra (Nenets and Chukotka) and taiga (Tungus) reindeer herding types (Mikhaylov, Klokov, Pestereva, 2016; Klokov, Mikhaylov, 2017).

### **Energy efficiency of reindeer breeding and climatic conditions**

As a biological species, reindeer got well-adjusted to the northern climate in the evolution process. The season migration of wild reindeer is arranged in such a way, that in the majority of situations the animals are found in the conditions beneficial for their bodily heat exchange, i. e. the system "operates" on the energy consumption minimization principle (Mikhaylov, Pestereva, 2013). In their turn, reindeer herder communities have adjusted their lifestyle to the environmental needs and spatial behaviour of the domesticated reindeer. Until recently, the connection between season migrations and domesticated reindeer herding energy were not in the centre of scientific discussions. Only several years ago, a computer simulation of the reindeer bodily heat balance and evaluation of the influence caused by a number of climatic factors, such as ambient temperature, wind velocity, snowpack depth and density, solar radiation, cloud cover etc. was carried out (Mikhaylov, 2013). In an environment beneficial for reindeer,

the heat balance is maintained through its physiological thermoregulation system (fur piloerection, changes in respiratory rate etc.). Such conditions are referred to as a thermoneutral zone (Parker, Gillingham, 1990). Below its lower limit (undercooling), the reindeer organism is forced to adopt the biochemical thermoregulation mechanisms in addition to the physiological ones, i. e. “to burn calories”: to spend the previously accumulated deposits of fat. In summer, in hot weather, when the upper limit of the thermoneutral zone is exceeded, the reindeer stop eating to avoid “overheating” of the organism, to slow down the accumulation of fat. By the end of the summer, they are skinny and weak. In winter, the excessive energy consumption caused by severe cold, wind, and deep snow, the death rate increases, and exhausted females cannot produce healthy fawns the following spring.

With the help of this simulation model and the data from 70 meteorological stations located in districts practicing various types of reindeer herding, the boundary conditions of the adult and young reindeer physiological thermoregulation system resistance to overheating or overcooling were determined (Klokov, Mikhaylov, 2017). The results provided a basis for explanation of a number of geographic peculiarities of tundra and taiga reindeer herding types. The heat balance conditions were proven to be just as important as the fodder resources of pastures, if not to say more.

The analysis of the data obtained through the model above revealed the periods when the heat balance parameters approach the thermoneutral zone limits or exceed them. There are two of such periods. In December-January, the risk of overcooling for fawns with the much greater thermolysis rate compared to adults is high; in July-August, adult reindeer may get overheated. The calculations demonstrate that in the continental part of Russia in the years of average meteorological conditions there is no risk of overcooling for domesticated reindeer, either adults or fawns, as the severe climate does not restrict domesticated reindeer breeding even in higher latitudes. However, in milder winters, reindeer herding conditions in the west and east sectors of the Arctic are better compared to the central zone (Taymyr and north of Yakutia).

The optimal conditions for reindeer in the warm seasons are found in the coldest areas of Siberia. It is the north of Taymyr, where the summer camp of the largest Eurasian wild reindeer population is found. Almost equal conditions are provided by the north tundra of the Yamal and Gydan Peninsula and in the north of Chukotka, i. e. in the areas of the best developed large herd breeding of the Nenets and Chukchi. The conditions in the southern part of tundra zones of the Yamalo-Nenets Autonomous

District, the tundra of the Nenets Autonomous Okrug and the Kola Peninsula, as well as the north of Yakutia, are a little worse. All these areas provide summer grazing pastures around the sea coast, where summer temperature is several degrees lower, wind and cloud cover are stronger. In the taiga-covered plains of Yakutia, as well as in the central part of the Kola Peninsula, the summer grazing conditions are less beneficial. In the south of taiga, the climate is even less suitable for summer grazing: here the time spent by the reindeer beyond their thermoneutral zone may last up to four months. The exception is the mountainous territories. Due to the vertical temperature gradient, at the altitude of around 1000 m the average daily temperature is approximately 0.6 °C lower. Moreover, compared to the forest landscape, the mountain tundra has stronger winds, which, from the heat balance prospective, equals to lowering the temperature by 2–3 °C. Therefore, bringing the reindeer into the mountains, to the altitude of 1500 m, equals to driving them several hundreds of kilometres to the north.

All in all, the simulation proved that the major role in the reindeer breeding success is played by the heat balance conditions of the summer period. This is why in taiga, the southern part of the reindeer breeding territories, the herders traditionally adopt some special techniques to avoid “overheating”. Thus, in East Siberia the permafrost creates icing on rivers that do not melt throughout the entire summer. The herders often keep their reindeer nearby. In the West Siberian taiga, an open wetland area, in summer the reindeer are kept in the open areas exposed to the strongest winds. According to the simulation results, the wind velocity growth from 0 to 4–5 m/sec significantly increased the heat expenditure of the reindeer. As the wind gets stronger, the heat balance fluctuations slow down. Bringing their herds to the wind-exposed areas, the reindeer herders do not only mitigate the negative impact of high summer temperatures, but also protect their reindeer from insects. In many taiga areas, the herders make special tents or shelters of thin poles and sticks to keep the animals away from the sun and insects (Kuriliuk, 1969: 297–299; Mukhachev, 1986: 41–53; Koz'min, 2003: 33, 66).

Though, as it has been noticed above, the reindeer are well-adjusted for cold winters, there are some extreme situations when they may die of the reasons that that are not taken into account by the heat balance equation. The first of them is ice crust, which usually appears in the pre-winter period, when the temperature close to zero followed by frost makes the crust impossible to break; in the winter thaw season, it emerges less frequently. In warm winters, several crusts may generate within the snow cover. For this reason, warm winters in the tundra may be worse than the cold ones,

especially near the sea where the sea freezes late or does not freeze at all. The terrain of the winter pastures is of great relevance. In the hilly tundra, large areas of the pastures do not generate the ice crust, except for little local areas. Staying in those territories for the winter, the herders can always find a place thin crust or crust-free areas. However, it requires some spare spaces in the pastures; if there are none, it is impossible (Makeev et al., 2014). Ice crust and the deficit of pasture land are, obviously, the main reasons of death of the domesticated reindeer in 2014 in Kolguev island, which is absolutely flat. Ice crust is the most dangerous for the reindeer living in the tundra along the Pacific coast of Chukotka. In the past, the Chukchi never used those territories for winter grazing; now, they call those areas the “risky herding zone” (Mironenko, 2000). Besides ice crust, fodder plants covered in ice are another threat: consuming them, the animals swallow a lot of ice, which may cause death of overcooling (Baskin, 2009). The herders are also familiar with the so-called “fawn blizzards”, the blizzards that occur in the fawning period, causing the death of the new-born reindeer.

The local climate conditions are obvious to determine the traditions of the herders, who consider them in choosing the routes comfortable for the deer, stick to them even when the fodder resources are exhausted. In Russia, there are three main reindeer herder spatial organization models.

1. Meridional spatial model is more typical for large herd tundra reindeer breeding in the plain areas, where the latitudinal zoning of the territory is highly distinctive. The pastures stretch from the north to the south sometimes for hundreds of kilometres from the tundra in the Arctic ocean coast to the forest tundra and north taiga. In the map, the pasture territories look dumbbell-shaped, with the narrow long middle part being the migration routes from the summer to winter pastures and back, and the wider ends corresponding to the circular routes in the winter and summer camping areas. The heat balance is optimized due to the stay within the comfortable climate area during summer, which allows the reindeer to accumulate enough nutrients for the winter. Moreover, the animals are less disturbed by insects, which is another additional energy consumption factor. Migration to the winter camps on the continent, far away from the sea, is intended to avoid the ice crust generation areas. In addition, migration to the forest give the people a chance to collect some wood for heating their houses. Due to the optimal combination of the climatic conditions all year round, this model is of great energy efficiency, and, provided with the sufficient fodder resources, of high economic feasibility. Being typical for large herd breeding practiced by the Nenets, Izhma Komi, and Chukchi, this model is the most common for the Yamal. The predominantly linear

direction of the migration routes is also typical for the tundra herding in the north of Yakutia (Andreev, Kutiliuk, 1989: 74–75).

2. The second model is practiced in the mountainous areas. Instead of the latitudinal zoning common for plains, it uses the vertical zoning of the mountains: the summer pastures are located in the mountain tundra, while the winter ones are at the foot or on the slopes of the mountains. It makes it possible to practice large herd reindeer breeding by the Izhma Komi in the Urals (the Lyamin river basin) and the Evens in the north-east of Yakutia. The mountain pastures are the main condition for existence of south reindeer breeding in Tofalaria, Tuva and Mongolia.

3. The third model is based on circular migration of the herds. The seasonal pastures are located relatively close to each other, within some tens of kilometres, within the same landscape zone; the herds migrate around a closed circle. The model may include one or several migration circles.

In the latter model, both animals and people save their energy due to the absence of long migrations. Different variants may be found in all the areas, but they are mostly typical for the south of tundra, forest tundra and the north of taiga. In the taiga territories, where the reindeer are mostly bred for transport, the seasonal migrations are often caused by the hunting needs, not by reindeer herding reasons.

Paradoxically, the circular model is also common for the north of tundra (such as in the north of the Yamal and Gydan peninsulas), and in the Arctic islands (Kolguyev and Vaygach). The all-season breeding without migration to the south may be provided by two conditions. The first is the fuel for heating the accommodation of herders. In the past, it was driftwood; today, the reindeer herders often use wood delivered by different mechanic transport. The second condition is the absence of ice crust, which, as proved above, in large territories mostly depends on the terrain.

Between the considered basic spatial models, some transition options are also possible, as the circles may “expand” into ellipses, and ellipses “grow” into dumbbell shapes. Sometimes the migration routes are more complicated. The complexity and irregularity of the seasonal routes may be caused by various reasons: the location of slaughter facilities, settlements, industrial infrastructure, neighbouring herd movement etc. The traditional routes are adjusted by the climate changes, that shift the freezing and breakup of rivers, facilitate the generation of ice crust in the pastures, cause “ice” rains, or the shrubs growing around the tundra (Stammler, 2008). As a result, the migration trajectory may be very complex and vary from one year to another: it is

especially typical for small herds of private reindeer breeders of the West Siberian tundra (Golovnev et al, 2016: 34–35; Kvashnin, 2009: 79–85).

Therefore, the ethno-ecological aspect of traditional reindeer breeding covers the selection of a spatial strategy, which maximizes fodder resources consumption efficiency through optimization of the bodily heat balance of the reindeer. Wild herds do it instinctively; reindeer herders use their experience and traditional knowledge to select the best migration route to keep the animals comfortable from the prospective of energy balance.

### **Ethno-economic aspect of reindeer herding energy balance**

The adopted traditional practices improve the efficiency of labour, and, therefore, of the energy spent by the herders on reindeer grazing. While the natural ecosystems “work” on the energy consumption minimization principle, it does not fit the socio-ecological systems. Energy saving as such is not the main purpose of the traditional communities. Their behaviour is subconsciously guided by the labour-saving archetype (Iamskov, 2005). However, the “minimum labour” techniques often appear to be the most energy efficient as well. Grazing energy consumption may be minimized in two ways: by letting the reindeer graze freely with the minimum interference of man, or, on the opposite, by training them to be obedient and easy to control.

Based on the collected material on reindeer herding and other traditional animal breeding in the north of Eurasia, French anthropologists (Stépanoff et al., 2017: 60) described five modes of herding: seasonal freedom, attraction, checking, watching and captivity. Such division appears right but quite artificial, as the actual reindeer herding systems normally combine several of the mentioned models, adopting different combinations during different seasons and under different conditions. Russian reindeer herding researches normally describe four systems: the controlled (herding) one, free, semi-free (free-camping) and grazing in limited territories (Mukhachev, 1986).

Free and controlled herd grazing are two opposite strategies. In the first option, the reindeer are not interfered at all; in the second one, they are kept under continuous control. It is achieved through a series of different practices, including the development of a certain structure of the herd and training separate groups of animals of different taming status. The free-camping grazing practiced in the taiga zones is, on the opposite, based on the independent (autonomous) behaviour of the reindeer that regularly return to the herders' camp on their own. Here the taming status and indirect methods of control are of critical importance.



Following (Ch. Stépanoff et al., 2017), it is possible to develop a fuller and more consistent grazing typology, classifying all controlling impacts on the reindeer into direct and indirect ones. It is worth noticing that the first are more typical for the tundra, and the latter for the taiga types of reindeer herding. The direct impacts (immediate control over the reindeer herd) include retention, turning, driving, putting together (собира́ние стада вместе), dissolution (dispersion??? — роспуск стада по пастбищу), drifting to a different place (Baskin, 2009: 111–121). To control the herd, the herder may use gestures, voice, ropes, herding dogs, approach the animals on foot, on the skis or sledges, riding a deer, or, sometimes, a horse, drive them with snowmobiles, ATVs, or in foreign reindeer herding even small helicopters.

To keep a herd under control it is essential to know where it is. The herder collects information through observing the animals, or indirectly, by studying their footprints, running around the herd, using a *botala* (a bell). Some herders use radiocollars, it is possible to use other technical devices, such as drones.

A critical condition for efficient herd control is accurate forecasting of the location of the entire herd or any of its lost parts. The knowledge of reindeer behaviour stereotypes helps detecting their likely location, saving the effort of the herders, leaving the herd unsupervised for some time. The main behaviour stereotypes of the reindeer are few: they normally move against the wind, run uphill or in the direction of other reindeer (usually, in the direction of the herd, or a detached group of reindeer outside the herd), follow the leader, return to the previous campsite, tend to leave the pasture where the herd has been grazing for over 3–4 days (Baskin, 2009: 69). During certain periods of time, more stereotypes may appear. Forecasting the location of the herd saves the effort, time and energy, as well as prevents the loss of animals. Knowing the reindeer behaviour, the herders may direct them in the right direction, “programming” their route for several hours or even days ahead. However, there is an alternative strategy that involved continuous control over all migrations of the herd.

Another critical condition for efficient herd control is its structure. As a rule, a herd consists of several groups of reindeer of different taming status and degree. Unlike individual taming used for riding and the so-called “bread” reindeers that live by the *chum* since early age, the herd control is based on fear. Fear of human is the tool the herder uses to drive the reindeer. Usually the animals develop this reflex by three years old, as they grow up. The dogs are of great help, since the reindeer fear them even more. The young deer are not afraid of people, which makes it almost impossible to control them. If the herder stands in their way, they just run by. Following their

intrinsic instincts, they run to the herd, or the wind, or uphill. Unlike them, adult she-reindeer know that they should run away from the man, which often makes them the herd leaders. The same reflex is developed by the riding reindeers. This is why driving young deer requires joining them to some adult ones, preferably females (Baskin, 2009: 112–113).

During herd grazing, the control is focused on the potential leaders, primarily adult females. Shifting them to the side of the herd, the man forces the herd to follow them in the required direction (Zadorin, 2016; Baskin, 2009: 117–119).

Free grazing as a temporary condition of the herd is used in different types of reindeer breeding. Even in controlled grazing, the herders sometimes leave the deer unsupervised. It usually happens in winter, when the deer are less agile due to the deep snow. And even though free grazing does not involve any energy consumption or effort, they may be required to gather the reindeer later. The effort may be saved, first of all, through the knowledge of deer behaviour sufficient for forecasting their location during the gathering period. Secondly, there is a series of special techniques classified as indirect controlling impacts:

- 1) attracting deer with smudge fires and/or shade tents, by offering them food (usually salt, or special fodder mixes);
- 2) complete restriction of movement by tying or keeping deer in folds (*corrals*);
- 3) long-term keeping in large enclosed areas of pastures;
- 4) various partial movement restriction techniques, such as cut-off and directing fences, scarecrow, tying deer to heavy sticks, hamshackling etc.

Partial movement restriction may also involve alternating tying of female deer and their fawns right after they are born. It is done to train the fawns to follow people from the early age, which keeps them tame for the whole of their lives. This is one of the taiga reindeer breeding “know-hows” of the Evenki (Turov, 1990; Sirina, 2012) and the Tofalars.

Totally free grazing is already beyond domesticated reindeer breeding. An example of it would be reindeer herding on Saint Paul Island (Alaska) the author observed in 2000. The reindeer were considered domesticated, as they were privately owned; however, for many years they had been living like wild, and would never let a man come closer than a shooting distance. Some of them wore radiocollars for two herders to detect the herd location right from their office, using computers. The reindeer slaughter was carried out by shooting them from a long distance with a gun. In fact, it was breeding of wild reindeer, i. e. the American analogue to what in Russia would be referred to as

a rational hunting farm, which was suggested to be called “hunting reindeer herding” by E. E. Syroechkovskiy (1986: 2011–231).

The opposite, “symbiotic” model of free grazing was observed by the author in the Tofalar settlement of Alygzher. Here, reindeer herding was maintained for transport: riding reindeer were used by the Tofalar hunters to move around during sable hunting season. Most of the time, the hunters lived in a village, while the reindeer were grazing freely in taiga. In autumn, all of them met in a certain place. During the hunting season, man and reindeer were united by the same work. After that, the people would come back to the village, and upon arrival the reindeer would be set free to run back into the taiga, where they lived on their own until the next season. There were only two people who lived continuously around the reindeer pastures to control the most significant events in the reindeer life, rut and fawn. In winter, both of the reindeer watchers were also engaged in hunting, at the same time watching the females and young deer that were not used for loading or riding. The taming degree of the animals was so high, that the Alygzher people did not even have to use any fences or lasso. According to them, a reindeer herder may only need a lasso to catch a wild deer that gets attached to the domesticated herd (PMA, Alygzher, 2014). It has been achieved through taming many generations of fawns from the moment of birth, as well as by treating the reindeer to salt, and other techniques.

Therefore, paradoxically, free grazing is underlaid by two opposite conditions: they are either so well-tamed and so predictable that people can leave them free for a long time, after which the deer would be caught relatively easy; or, on the opposite, they are practically wild reindeer that are even impossible to approach.

Grazing within a fence is, basically, free grazing in a limited space. The fences reduce the effort directly linked to the reindeer control, but at the same time increase the overall energy needs of the reindeer herding system. Fence building is effort intensive and energy consuming, but it makes it possible to use less qualified labour. At the level of the system, using fences actually means replacement of the mental effort with physical one.

Thus, according to the unpublished research of N. Ssorin-Chaykov, the transition from free-camping grazing to grazing in the limited territory, which was common in Evenkia in the 1970-s, weakened the “symbiotic” relations between man and reindeer. Accustomed to fences, the reindeer became more attached to their place of residence. Within the fence, they would wander around the perimeter as a dense crowd, trampling the pasture down very soon. Outside the fence, the animals would become timid, fear of

grazing in small groups, disoriented, unable to return to their stock or pasture (Klovov, Khrushchev, 2004: 112).

There is only one taiga reindeer breeding cluster in Evenkia that has survived to the present day: this is the village of Surinda. During autumn, the reindeer here are kept within fences since the end of August to the end of October, until the snow becomes deep enough to keep the reindeer together. Moreover, in spring the she-reindeer in fawn are transferred to the stock for the fawning period. Within the fence, the reindeer are under supervision of the herders who maintain smudge fires and sometimes treat the animals to some salt. Therefore, the limited space grazing of the Evenki taiga reindeer herding tradition has become an addition to free-camping reindeer breeding (PMA, Surinda, 2014)

Another fence-using tradition has established on the Kola Peninsula, where the traditions of Sámi and Izhma Nenets reindeer herding have mixed with each other. Here, in the cooperative of Tundra, the two different grazing models are combined: the Sámi free grazing from June to November, while the reindeer are in the tundra zone, and the controlled Izhma Komi grazing from December to May, as the reindeer are at grass in taiga. A wire fence over 150 km long stretches along the borderline between tundra and taiga, dividing the winter pastures from the summer ones (Abramov, 2015: 27).

Using such fences in combination with snowmobiles enables the reindeer herders to work in a semi-settled manner, practicing shift method. This is a solution for adopting the traditional Sámi free grazing model for modern conditions (Abramov, 2015: 31).

The listed traditional ways of minimizing effort and energy consumption are of information-related nature. These are low energy controlling impacts used to prevent much bigger energy losses.

### **Reindeer breeding energy in the ethno-cultural context with respect to accultural processes**

The traditional reindeer breeding energy saving mechanisms described above do not remain unchanged. They are continuously transforming under the influence of various accultural processes as they integrate into the industrial and post-industrial society. Hydrocarbon burning energy is gradually replacing the natural environmentally friendly fuels, such as wood for heating and live reindeer as tractive force. After the introduction of tractors, ATVs and snowmobiles (the so-called “snowmobile revolution”), the reindeer camping sites got equipped with mobile petrol power stations.

The herders learned driving off-road summer vehicles, such as ATVs and others. The “snowmobile revolution” (Pelto, 1973) is developing into a larger, “petrol” revolution: the snowmobiles were just the beginning. The new reindeer herding evolution stage may be referred to as “petrol reindeer herding” period.

The possibility of using mechanic vehicles instead of reindeer makes it possible to pay less attention to taming; the opportunity of covering large distances by mechanic vehicles reduces the need for good reindeer behaviour knowledge. According to the Yamal herders, “if in the old times the people of tundra used to talk of reindeer, life, and children”, now they tend to discuss the petrol prices and the phones they and their children have (Perevalova, 2015: 45). In the past, they complain, it was better: “...there was no electricity, no beer, no TV, no computers, and all attention would be paid to the herd. Now the snowmobile requires attention: buy some petrol, buy some spare parts... All the time is spent on the machines, not on the reindeer” (Perevalova, 2015: 45).

The evolution of socioecological systems of reindeer breeding tends to gradually replace the low energy controlling impacts typical for traditional practices with the power methods. It is accompanied with increasing energy consumption within the system itself, which also yields the growing need for finance to purchase vehicles and power supplies. Petrol has become the main condition for the well-being of a nomadic family. The price of fuel is the question of critical importance. In today’s reindeer breeding it depends, first of all, on the prices for the energy sources, i. e. petrol, and the possibility of fuel delivery to the nomadic camps.

The growth of overall energy consumption goes hand in hand with the simplification of the controlling impacts; the level of mutual adjustment of man and domesticated reindeer is falling, i. e. the reindeer are getting de-domesticated. The transition of reindeer herding to the “external” energy sources results in gradual decline in the relevance of traditional herd control practices.

From the environmental point of view, the petrol revolution is an intermediary process, a “re-adjustment” of the socio-ecological system. In the past, the adjustment mechanisms used to be mainly focused on the maintenance of balance with the natural environment. But now, after the petrol revolution the adjustment mechanisms intend to solve another priority task: adjustment of reindeer breeding to the changing socio-economic conditions. As proven by K. Istomin (2015: 23–24), such transition leads to the decline in nomadic mobility and violation of traditional practices which used to prevent the exhaustion of fodder resources, maintaining the environmental stability of the system.

The next stage of the socio-ecological reindeer breeding system evolution related to the further intensification of acculturation may be referred to as “digital reindeer herding”, similar to the popular term of “digital economy”. It is manifested through the popularization of electronic gadgets, particularly electronic communication devices (cellular and satellite phones), GPS navigators and various leisure devices (TV, multimedia players, video games etc.) among the nomad reindeer herders (Stammler, 2013; Istomin, 2015; Golovnev et al., 2015: 64–65). In the near future we may expect massive adoption of radiocollars and drones, reducing the overall saving of energy and effort spent on search of the reindeer, therefore, saving the snowmobile and ATV fuel. If the transition from the traditional to “petrol” reindeer herding is accompanied with the growing “external” energy expense, the transition to “digital” reindeer herding shall be linked to the opposite trend: energy (particularly, petrol) saving by decreasing the number of trips for herd control, and the optimization of the pasture spatial structure.

Here comes a question, to what extent the transition will result in loss of traditional knowledge and skills, and how big its impact on the ethnocultural specificity of the community would be. As remarked by Abramov (2015: 31) the studies of reindeer grazing practice of the Kola Peninsula demonstrated that the majority of tactic tasks solved by means of a snowmobile today are impossible to fulfil with a sledge. It may be suggested that the transition to digital reindeer herding will cause the traditional practices, previously used to maintain the balance by means of systematic self-organization, to be replaced with purposeful regulation and control methods.

Together with that, considering the slowly growing demand for the ethnographic tourism services, it cannot be excluded that at a certain point the “retro reindeer herding”, with the minimized use of any external energy sources and electronic gadgets, may attract interest of those who wish to see a true-to-life historical reconstruction of the old local traditions.

This way, the traditional reindeer herding energy system is based, on one hand, on the optimal spatial strategies determined by the geographic factors and conditions, and on the other hand, on the energy-saving traditional animal control practices. From the energy point of view, three possible evolution scenarios may be described: the “petrol”, the “digital” and the “retro” reindeer herding scenarios. At that, the transition from the traditional to “petrol” herding is accompanied with the dramatic increase of the overall system energy consumption, while the tendency for “digital” and “retro”

herding will obviously be characterized with less energy consumption and transition from the systematic self-organization to stricter control.

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## **Энергетика северного оленеводства: управляющие воздействия в экологическом и этносоциальном контекстах**

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*Устойчивое функционирование социально-экологических систем обеспечивается, во-первых, за счет относительно мощных потоков энергии, связанных с взаимодействием материальных компонентов, во-вторых, за счет имеющих слабую энергетику управляющих воздействий, контролирующих эти потоки. Северное оленеводство основано на традиционных моделях контроля потоков биологического вещества и энергии, сложившихся у разных этнических общностей в различных типах географических ландшафтов («тундра кормит оленя — олень кормит человека»). Эти модели включают устойчивые наборы традиционных практик, в составе которых: различные способы индивидуального и группового приручения животных, прямые и косвенные методы управления их поведением, пространственно-временные модели*

сезонных перемещений оленьих стад и др. В совокупности они обеспечивают симбиоз между сообществами оленеводов и популяциями домашних оленей.

Энергетика традиционного оленеводства построена, с одной стороны, на оптимальных стратегиях перемещений в пространстве, которая за счет оптимизации теплового баланса организма оленя позволяет получить максимальный эффект от использования кормовых ресурсов пастбищ. С другой стороны, она связана с использованием традиционных практик, благодаря которым достигается экономия труда и, следовательно, энергии, затрачиваемой пастухами на выпас оленей. Адаптация традиционного оленеводства к индустриальному и постиндустриальному обществу выражается в переходе к «бензиновому» и «цифровому» оленеводству. Первый переход сопровождается резким увеличением общесистемных энергозатрат, а второй, по-видимому, приводит к их снижению.

Ключевые слова: оленеводство, коренные народы, климат, тепловой баланс, традиционные практики, социально-экологические системы, Север России, Сибирь.

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