Let us speak energy and surface footprint : the PAD concept

To limit land use, the cluster concept, developed offshore during the seventies, has been transposed to onshore development. A PAD (**Figure 1**) consists of drilling several wells (between 5 and 15) from a same surface tie-in point and using horizontal drains to reach different reservoir targets. A full-field development with a total of 300 wells will require about 20 PADS, a CPF (Central Processing Facility) and a network system to connect PADS and CPF. The PAD model considerably reduces land use, as many wells are concentrated on a small surface area. It is particularly suitable for the development of unconventional resources, whose production requires many wells. Considering that a PAD represents a surface of 4 acres (between 1 and 2 ha) and a well drains between 0,5 km^2 and 1 km^2, a PAD of 10 wells will drain 5 to 10 km^2 of subsurface for a footprint of only 2 ha. The process is therefore highly efficient.

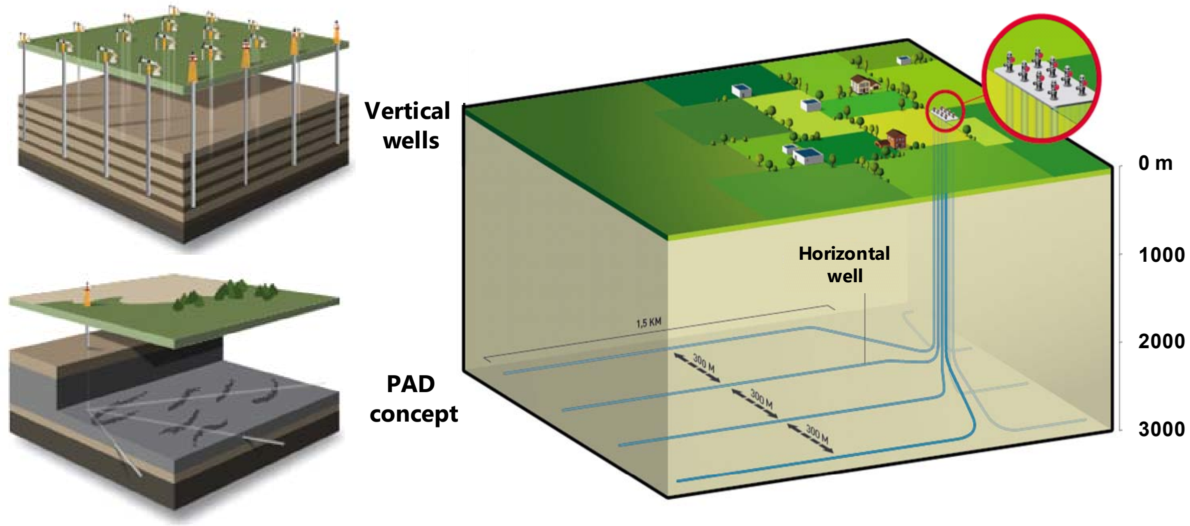

Figure 1 – Onshore drilling PAD considerably reduces surface land use

Looking now at a single PAD, land use will vary considerably depending on the phase envisaged. During the drilling (and also fracturing when dealing with unconventional resources) phase, the surface of the PAD will be very busy over a surface range of 100m x 200m, the space being shared between the drilling rigs and all kinds of trucks carrying drilling muds and fracturing products (water, chemicals and sand) as well as pumping equipment (**Figure 2**). By contrast, during production, a pad of 10 wells will only occupy a few 1000 m^2 for wellheads, flow lines and the primary separator.
Drilling and fracturing operations will be the main source of nuisance including noise, dust, light and visual pollution[1]. The truck traffic[2] significantly increases the risk of accidents and represents potential damage to existing roads. Most unpleasant odors come from the drilling & fracturing fluids or from fuel used at the drill site. In any form, natural gas is basically odorless and colorless, but it is also flammable and can be lethal to humans if inhaled in large quantities.

Reducing land use means first optimizing the number of wells by correctly identifying the production zones, but also optimizing well architecture by drilling longer horizontal drains and possibly using the opportunity of multi-drain technology (several re-entry points for a same vertical trunk).

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[1] The height of a derrick is around 35 meters (compared with a wind turbine, which stands at 50 to 100m)

[2] When developing unconventional resources, the total truck movements during the construction and development phases of a well are estimated at between 7,000 and 11,000 for a single ten-well pad. Report for European Commission DG Environment AEA/R/ED57281 Issue Number 11 28/05/2012

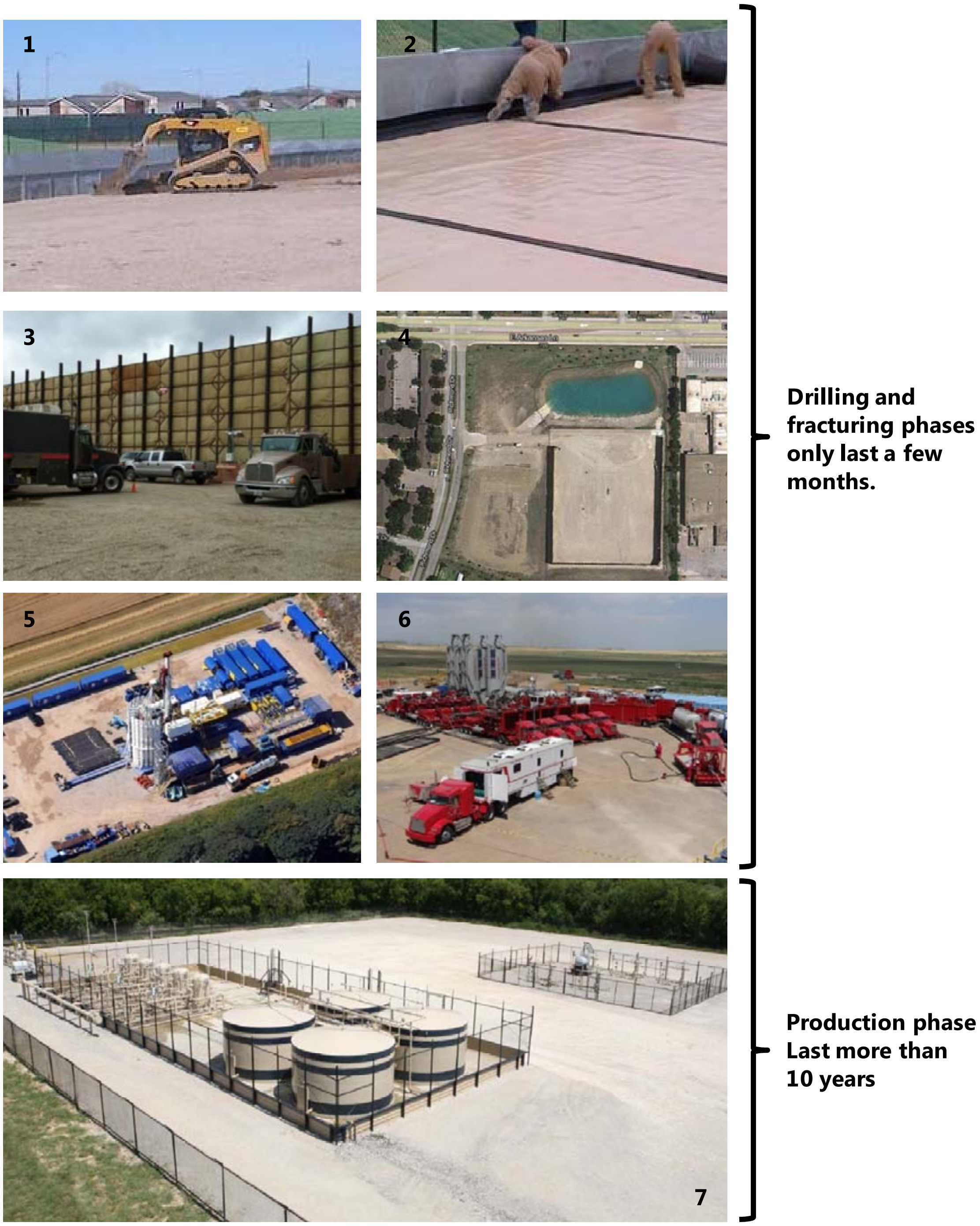


Figure 2 – The life of a PAD starts with a land-leveling phase, followed by the installation of a liner and the construction of a noise abatement wall. The main nuisances are generated during the drilling and fracturing phases. During the production phase the PAD is reduced to a well area and a storage area and remains relatively uncluttered.

The second leverage lies in the optimization of operational time (rig skidding and moving, bit selection to improve penetration rate and reduce tripping time, casing and cementing operations). It is interesting to note that the reduction of land use is totally consistent with economic optimization.

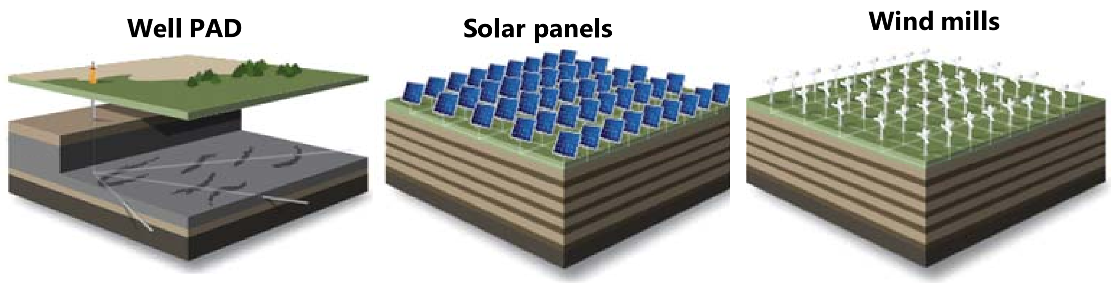
The first key to reducing visual nuisance lies in the appropriate use of natural topographic features. The visual impact can also be greatly attenuated by using vertical tanks and by directing lights downwards and to the drilling platform. More generally, the use of shields will prevent undesired illumination of residences, roads or other buildings in the surrounding area. Once the operations are complete, the site will be replanted.

As for other issues, a noise baseline will be established before any operation starts. To reduce the noise to a maximum of 55dB during the day-time and 45dB at night, it is advisable to enclose rigs in acoustic barriers and to put equipment (pumps, compressors, turbines for power generation) in noise-filtering containers. The new generation of rigs, directly connected to the electricity network to avoid use of field power generators should be preferred to diesel rigs. Finally, as for visual concealment, the relevant use of natural topography or forests can be of a great help in attenuating noise.

Road traffic is another key issue that has a sizeable impact on the surface footprint: noise and light, exhaust fumes, increased risk of accidents, damage to roads. After establishing a road traffic and road state baseline, rules and circulation plans will be defined in collaboration with local authorities and communities. A general driving scheme for road optimization will be implemented, including severe rules stipulating speed limits and very restricted night traffic in urban areas. Drivers of all service companies will be properly trained and heavy sanctions will be applied if the basic rules are not respected. Finally, when possible, water and oil & gas should preferably be transported by pipelines, to limit number of trucks.

Comparaison with renewable energies

In **Figure 3** we have compared the land used by oil, shale gas, solar photovoltaic and wind turbine projects. For oil and gas, 10-wells PAD of 300m x 300m (this includes the surface of piping) producing over a 20-year period respectively an average of 420 bbls/day of oil (total reserves of 3Mbbls per well) and an average of 100 bbls/day of shale gas (total reserves of 3bcf equivalent to half a million boe[3]) has been considered.



	Duration (years)	Primary (MWh/m^2)	Efficiency	Secondary (Mwh/m^2)	Ratio
Solar	20	35	0,15	5	28
Wind	20	0,51	10	5	29
Oil	20	499	0,3	150	1
Shale gas	20	81	0,5	41	4

Figure 3 – The onshore PAD concept has a much smaller footprint than that of wind turbines and solar panels.

Efficiencies of 30% for oil power plan and 50% for gas power plan have been applied. For solar power, data from eastern Oregon[4] (600 W/m^2, 8 hours sunshine per day) were used, taking into consideration a15% efficiency for the photovoltaic cells. Finally, the data from the Roscoe wind farm[5] (627 turbines,

[3] 1Mboe = 1,628,200MWh
[4] http://zebu.uoregon.edu/disted/ph162/l4.html
[5] http://www.windmillgallery.com/america/roscoe-wind-farm.html

3MW each installed on a 100,000 acre[6] land space, 15 hours of wind per day) was used with a 10% land use (90% of the area around the wind turbines can be used for other activities such as agriculture). To produce a same amount of power, solar panels and wind turbines require 30 times more land use than oil and 7 times more land use than shale gas than shale gas.

This is not surprising, as the production of fossil resources (oil, gas, coal, uranium) concentrates a large amount of energy previously spread within the subsurface, in a single point of the surface (the well), whereas solar and wind systems directly collect energy naturally dispersed in the atmosphere on the surface.

[6] 1 acre = 4047 m^2